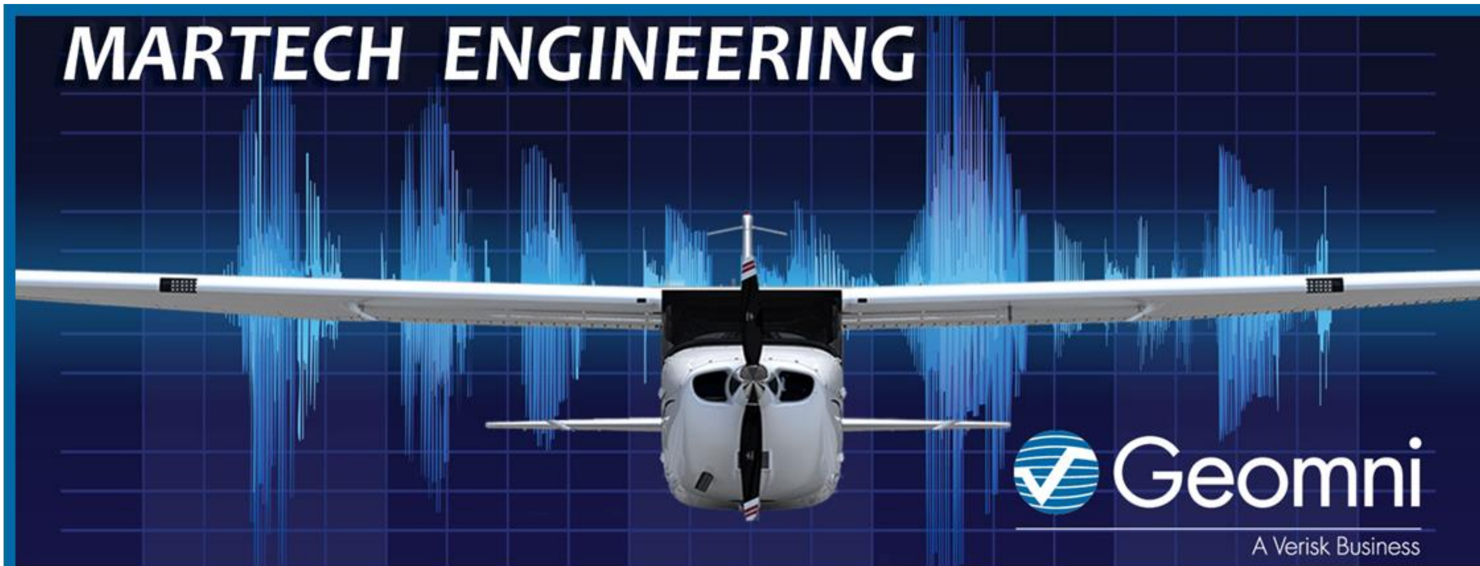
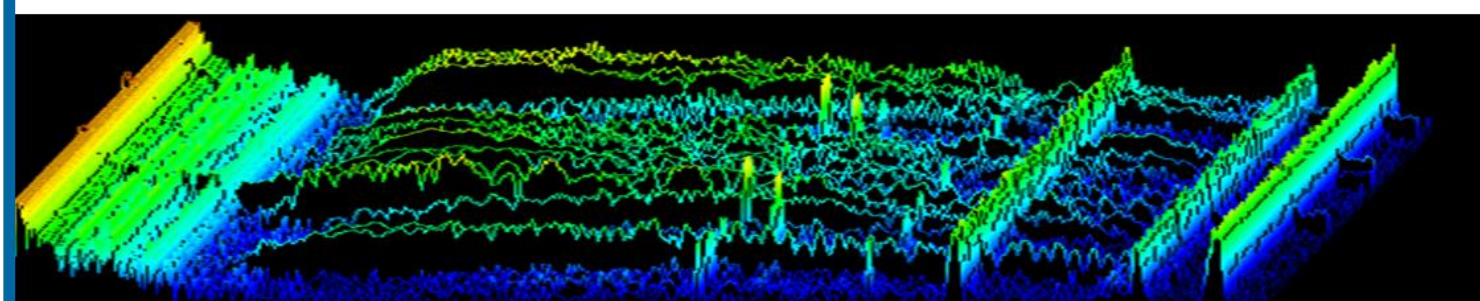


FCC Flyover Report

CITIZENS CABLE VISION
Floyd-Combined, VA



Test Summary

PSID Number:	002537
Plant Miles:	220
Date Tested:	2018-03-05
Test Frequency:	133.2625 MHz
Flyover Score:	100.00%
Average Intensity:	0.40

Mar-Tech Engineering

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Jacksonville, Florida 32225
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Summary of Test Results

System: **CITIZENS CABLE VISION: Floyd-Combined, VA**
Test Date: **March 05, 2018**

A fly-over test for the above system was performed to assess the system's signal leakage in the aeronautical band (108-140 MHz) as required by the FCC. The purpose of the signal leakage testing is to identify and locate any non-complying leaks (leaks in excess of 10 µV/m at 1,476 feet (450m)). Included in this report are a description of the test process, test results, probability graph, list of relatively high readings, and a map that shows the system boundary, flight pattern and locations of high readings. A separate interactive map is supplied in a KMZ file format and it is provided to aid our cable customers in quickly identifying the physical location of leaks.

<u>Summary of the Results:</u>

1. Number of sample points .... 1779 points
2. Number of points > 10 µV/m .... 0 points
3. Maximum leakage Level .... 7.42 µV/m
4. Average Leakage Level .... 0.40 µV/m
5. Percentage of points < 10 µV/m 100.00
6. F.C.C. Requirement Result: .... Pass

How to Use this Report

1. All leaks that have a valid Signal to Noise Ratio (SNR) are visible within the KMZ file. Leaks that are very close to a single major leak are collocated into that major leak source and the center of the leak is represented by that major leak source point. Values of zero in the leakage level indicate a location where no leakage signal was detected with sufficient SNR to validate it as a leak.

2. The leak locations depicted on the map are our best estimate of where the leak is, but they may not be the precise location of a leak. Please use this as a starting point when looking for the cause of a leak.
   a. The distance to the actual leakage point is typically less than half of a nautical mile from the depicted leak location.

3. Although all leakage levels with a valid SNR are mapped, only the leakage levels of 10 µV/m or greater, at the 450-meter altitude, are out of compliance. The non-FCC leak levels (<10 µV/m) are only mapped in the KMZ file to aid the cable company in identifying potential areas of leakage concern.

4. The provided KMZ file can be viewed in Google Earth Pro, which is available for free download and installation at the following link: https://www.google.com/earth/download/gep/agree.html
   a. After installing Google Earth Pro, simply double click on the KMZ file and Google Earth Pro will be started and the tested area/results will be shown in Google Earth Pro.
   b. It is recommended that you <u>do not</u> save each test area in your "Temporary Places" folder upon exiting the program. If you do, then after viewing multiple KMZs the performance of Google Earth Pro may become slow and require a reinstallation of Google Earth Pro.

Test Process

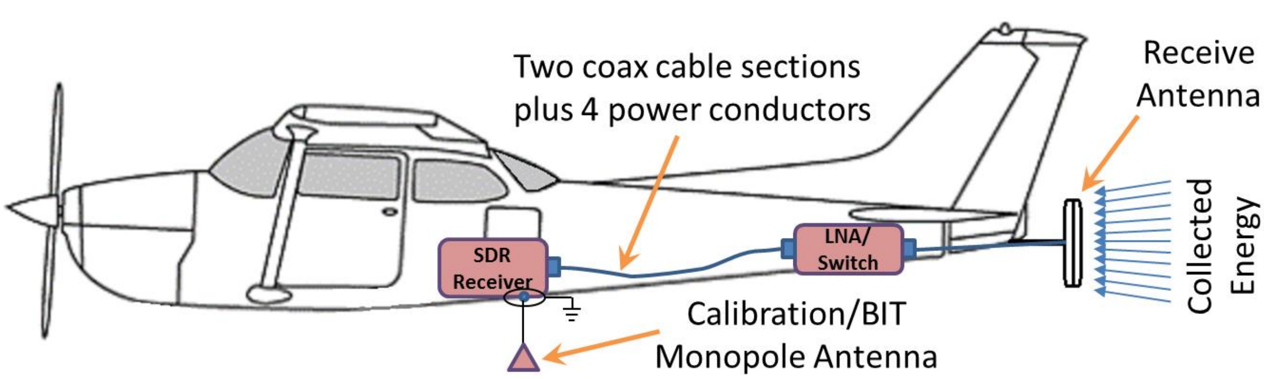
Approximately 30 days prior to the start of testing, the cable customer is sent a map of their system to be tested to confirm that the system boundaries are accurately captured. After the cable customer's verification of the system boundaries, the test system database is loaded with the cable system boundary along with a current USGS Digital Elevation Model (DEM). The USGS DEM is used to ensure the test system has an up to date ground elevation database for the entire area to be flown. This is required so that the test system can automatically adjust actual aircraft height to the FAA equivalent test height of 450 meters.

A week prior to the start of testing, the test frequency is confirmed. The frequency selected is verified that it won't impact locally used FAA frequencies in that area. The frequency is also confirmed that it complies with the FCC's offset rules, which require odd multiples of 12.5 kHz in the 118-137 MHz band (FAA Communications band) and odd multiples of 25 kHz in the 108-117.9 MHz band (FAA Navigation band). Given our comprehensive map of cable customers and frequencies used, we also verify that the frequency selected will not be impacted by adjacent cable operators in that area.

If we provide signal injection equipment to the cable operator, then that equipment is delivered to the cable operator technician prior to the test. We work with the local technician to confirm test equipment is installed and operating at the proper frequency and level prior to the commencement of testing. If the cable operator's equipment is being used, then the Mar-Tech test lead will confirm with the cable operator that the equipment is operating at the proper frequency and level as set by prior to the commencement of testing.

Initial Setup and Calibration

The Mar-Tech Digital system uses a comprehensive self-contained Built-In Test (BIT) to verify operation of the system. During startup the day of testing, the internal BIT is used to confirm that the system is tuned to the correct frequency and all components are functioning properly. During testing, the BIT periodically rechecks the system during flight to verify that the system is continuing to operate properly. The BIT has three separate paths that it can run a test signal through the system. The first closed loop path is to verify that the Software Defined Radio (digital receiver) is functioning properly. The second closed loop path is to verify that the aft mounted Low Noise Amplifier (LNA) and switch are operating and the receive path gain is measured. This second path is also used to set the system calibration level continuously during the flight to ensure all measurements have a calibrated reference level. The final path is a brief external pulse pattern that is used by the system to verify the aft mounted antenna is fully functional and it also provides a full end to end check of the system. Although antennas are highly reliable devices, this external radiation test is key to knowing that the full system is functioning properly throughout the testing.



Mar-Tech Test Aircraft Configuration

System Operation

The Mar-Tech Digital system is a smart system that is left on continuously during flight. The system knows when it is in or out of the customer's cable system boundary area and thus, it knows when to collect energy and when not to. In addition, the system knows its altitude above the terrain continuously throughout the flight based on the USGS DEM and thus, the system is able to correct collected data back to the equivalent level as if the system were flying precisely at the FCC required flying altitude of 450 meter (1,476 feet) above the terrain. The system is designed so that potential hot spots are highlighted in real-time to the crew to enable the crew to provide technician's immediate feedback on notable leakage locations.

Because the system is autonomous with real time processing, we are now able to provide quick look feedback to the cable operator as to what the preliminary test results are. The detailed data from the test must still be post processed to more accurately collocate and geo-locate the leakage findings to a leak point on the earth.

During system operation, the system corrects for the following factors:

1. Antenna Gain, which is dependent on the collection frequency
2. System Calibration, which is continuously determined through BIT
3. Flying Altitude, which is continuously recorded and adjusted to be height above terrain
4. Signal to Noise Ratio, by continuously measuring the ambient RF noise levels

The field strength and background noise are continuously measured to determine if the Signal is at least 15 dB above the noise levels, which means the signal is 31 times stronger than the noise levels (SNR of 15dB). The system is capturing and processing data at a Nyquist rate that is twice the rate at which the data is recorded into the database (once per second). An aircraft flying 135 kts is covering 228 ft per sec and since the antenna can detect leakage signals up to 2 miles away, the typical leak may be in range for up to 50 sample periods. That is another reason our digital system is able to more precisely locate the origination source of a leak on the ground. During post processing of the data, we further refine the location of a leak by examining signal characteristics and leakage data from adjacent flight paths to better geo-locate the leak on the earth.

All data is sent back to Mar-Tech headquarters for post processing and certification of the results. A report is then issued to the cable operator along with an interactive "KMZ" file that allows the cable operator to pan around their property to more precisely identify the location of leaks in the cable system. Any leakage energy with sufficient SNR is mapped to enable cable operators to identify potential integrity issues in their system.

Test Equipment & Calibration Schedule

Test Equipment	Calibration Schedule
Aircraft (e.g. Cessna 210, BE76, …)	Annual Inspection
Aircraft Folded Dipole Antenna	Tested Continuously in Flight
Monopole Calibration Antenna	Tested Continuously in Flight
Aft Mounted LNA & Switch	Tested Continuously in Flight
SDR Digital Receiver System	Tested Continuously in Flight
SDR Precision Radio	Annual Calibration
Garmin WAAS Enabled GPS	Annual Inspection
Signal Level Meters (Wavetek SAM)	Annual Calibration
Signal Generators (HP 8647-A)	Annual Calibration

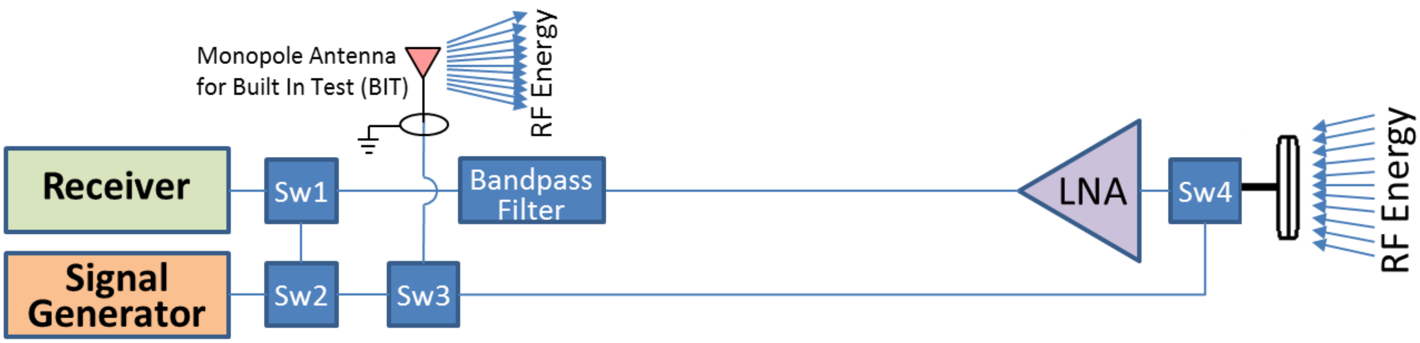
Test Results and Analyzed Data

Apply Frequency Correction Factor to Data

Frequencies below 108 MHz: (Data Sample) + 20 * log (f/108) µV
Frequencies above 140 MHz: (Data Sample) + 20 * log(f/140) µV
where "f" is the test frequency in MHz

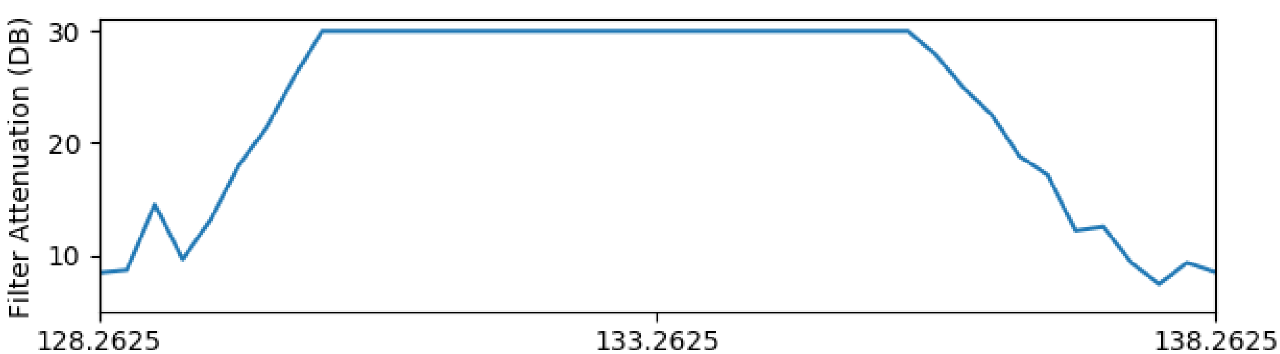
Calibration of the Receiver

After startup, the system quickly performs a complete self-test by sending a test tone through Switches (Sw) 1, 2, 3 & 4 to validate system operation. A simplified System RF Block Diagram is shown here:



System Radio Frequency (RF) Simplistic Block Diagram & Calibration Paths

After receiving the Cable System's test frequency, the system then sets up to assist the operator in tuning the Bandpass Filter to be centered within ±0.4% of the System Test Frequency of 133.2625 MHz. The actual measured bandpass filter response from this test are shown here:



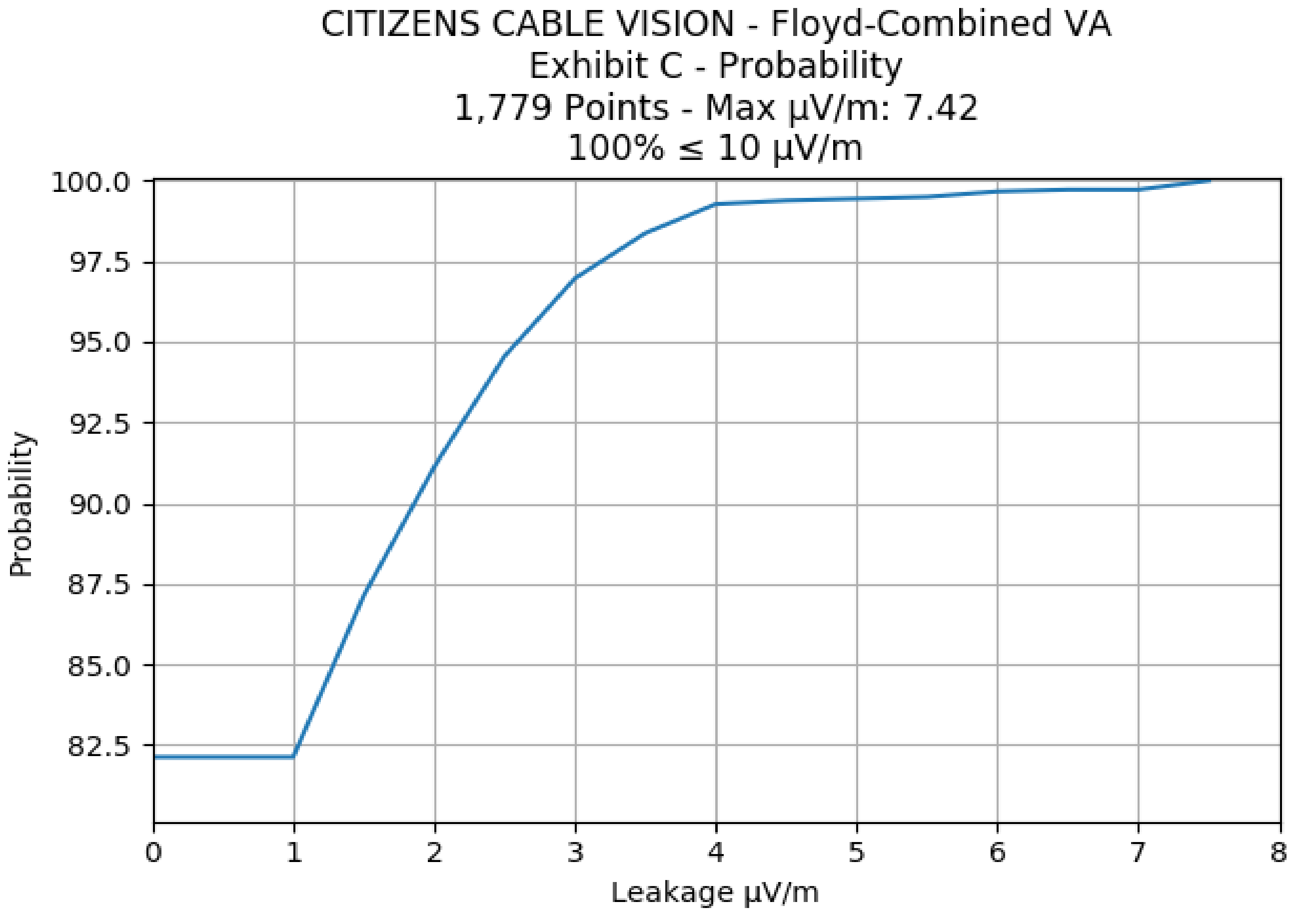
Bandpass Filter Alignment Test Results

With the filter centered properly, the system then verifies the system gain both in the closed loop (no external RF energy) and externally to ensure the aft mounted antenna is fully functioning. This tested is repeated many times during the flight, but here are the initial gains from this setup calibration.

Effective System Gain: : 14.69 dB (greater than 10 dB is required)
External Path Validation: 44.13 dB (relative strength of signal above minimum allowable)

Finally, the average flying height, above ground level, for this test was 2,619 feet. As mentioned previously, the system is continuously correcting the collected data back to the equivalent level as if the system were flying precisely at the FCC required flying altitude of 450 meter (1,476 feet) above the terrain.

Probability Graph



Relatively High Readings

MAJOR LEAKS (> 10 µV/m):

Leak #	Coordinates	Leak (uV/m)
	No Major Leaks	

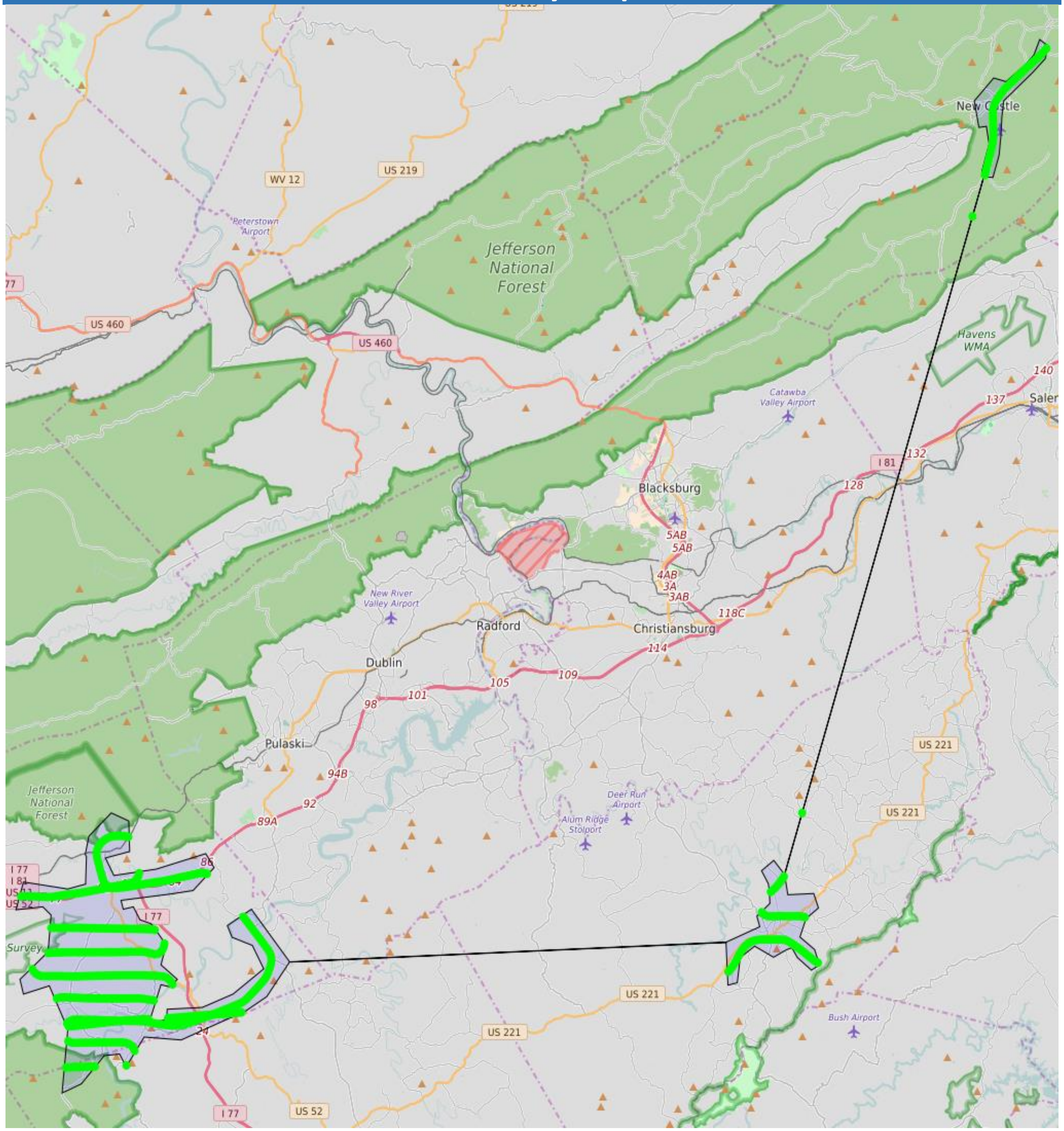
MINOR LEAKS (First 100 leaks that are ≤10 µV/m):

Leak #	Coordinates	Leak (uV/m)
1	37.536469,-80.060120	7.42
2	37.536983,-80.059486	7.38
3	37.535984,-80.060753	7.09
4	37.534565,-80.062767	7.06
5	37.535038,-80.062080	7.01
6	37.537491,-80.058876	6.00
7	37.534122,-80.063438	5.97
8	37.535500,-80.061432	5.96
9	37.538006,-80.058250	5.53
10	37.539062,-80.057091	5.20
11	37.538540,-80.057678	4.66
12	36.954716,-80.865479	4.50
13	36.817005,-80.985046	4.13
14	36.954559,-80.866280	3.98
15	37.526123,-80.075249	3.88
16	37.527088,-80.073814	3.87
17	36.816975,-80.986023	3.76
18	36.924805,-80.319878	3.76
19	37.525665,-80.075874	3.75
20	36.951435,-80.885086	3.74
21	37.530407,-80.068970	3.74
22	36.817051,-80.984138	3.72
23	36.945034,-80.944580	3.71
24	36.954430,-80.867119	3.70
25	36.950405,-80.891098	3.66
26	36.951603,-80.884186	3.62
27	36.924732,-80.319046	3.61
28	37.526611,-80.074516	3.52
29	36.924805,-80.314079	3.52
30	37.533657,-80.064148	3.49
31	36.924778,-80.314865	3.49
32	37.527573,-80.073128	3.49
33	36.950268,-80.891953	3.42

34	36.924862,-80.304146	3.33
35	36.817528,-80.966202	3.32
36	36.944927,-80.943756	3.31
37	36.924767,-80.315689	3.26
38	36.952904,-80.876411	3.26
39	36.953045,-80.875610	3.26
40	36.950546,-80.890221	3.23
41	36.954159,-80.868835	3.23
42	36.951736,-80.883347	3.23
43	36.951282,-80.885925	3.18
44	36.951893,-80.882469	3.17
45	36.938499,-81.002953	3.16
46	36.924862,-80.310761	3.13
47	36.953991,-80.869690	3.10
48	37.528049,-80.072441	3.08
49	36.949772,-80.895370	3.07
50	36.954849,-80.864616	3.06
51	36.817108,-80.982246	3.03
52	36.817490,-80.968094	3.03
53	36.954285,-80.868011	3.03
54	36.817154,-80.981308	3.00
55	36.949306,-80.899719	3.00
56	36.924862,-80.303307	2.98
57	37.539589,-80.056511	2.97
58	36.817081,-80.983200	2.96
59	36.924904,-80.320648	2.96
60	36.924866,-80.304985	2.94
61	36.949390,-80.898804	2.93
62	36.924847,-80.302505	2.90
63	37.530880,-80.068268	2.87
64	36.938511,-81.002083	2.83
65	36.924728,-80.318184	2.83
66	36.948944,-80.903152	2.83
67	36.955383,-80.861191	2.82
68	36.938499,-81.003777	2.81
69	36.817497,-80.967163	2.78
70	36.924912,-80.293465	2.78
71	36.953186,-80.874771	2.77
72	37.512836,-80.093826	2.76
73	36.949860,-80.894531	2.75
74	36.924904,-80.294289	2.75
75	36.950119,-80.892776	2.74
76	36.816917,-80.986900	2.73
77	36.924824,-80.313225	2.73

78	36.949993,-80.893654	2.70
79	36.951138,-80.886803	2.67
80	36.925072,-80.321465	2.67
81	36.924881,-80.309921	2.67
82	36.834816,-80.952278	2.65
83	36.952023,-80.881630	2.63
84	36.952751,-80.877319	2.62
85	36.952179,-80.880753	2.62
86	37.513336,-80.093132	2.62
87	37.529945,-80.069656	2.62
88	36.948753,-80.904900	2.60
89	37.525200,-80.076622	2.60
90	36.950699,-80.889359	2.59
91	36.924862,-80.311562	2.59
92	36.955513,-80.860306	2.55
93	36.938557,-81.001274	2.55
94	36.945213,-80.945381	2.54
95	36.953320,-80.873886	2.53
96	37.512344,-80.094475	2.53
97	36.834820,-80.951500	2.52
98	36.924747,-80.316544	2.49
99	36.834820,-80.953064	2.46
100	36.817184,-80.980415	2.46

Summary Map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Forest
New Castle
WV 12
US 219
Peterstown
Airport
US 460
US 460
Havens
WMA
140
137
Salem
Catawba
Valley Airport
I 81
132
128
Blacksburg
5AB
5AB
4AB
3A
3AB
118C
New River
Valley Airport
Radford
Christiansburg
114
Dublin
105
109
101
98
Pulaski
94B
US 221
US 221
92
89A
Deer Run
Airport
Alum Ridge
Stolport
Jefferson
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Forest
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I 81
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Survey
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I 77
US 52