Examining Spectrum Activity Using
Using a 'Real-Time' {Digital} Spectrum Analyzer

Welcome to the 4th Quarter 2015 CSEI Technical Report.

In the past, using these articles, I've examined a variety of issues that I felt were pertinent to the industry and those reading them. In this report I had originally intended to provide a follow-up to my first report on this subject; Signal Leakage Testing at 700 to 900 MHz, Part One (1st Qtr 2013). However, after recently patrolling a cable system for leakage in the 852 MHz to 869 MHz Public Safety Band (CEA/EIA channels 134 through 136), I found that the 2nd report would have been virtually identical to the one of two years ago, in that the leakage mechanism in the 2nd system patrolled remained virtually the same. To be sure, there were a great many very low-level leaks found, however, none came remotely close to exceeding FCC limits for the bands tested. And the leakage *mechanism* also appeared to remain the same, with the top three contributors appearing to be (a) leakage at poles and pedestals, likely the input & output coaxial connectors (and perhaps unterminated tap spigots), (b) coaxial splices, and (c) in-home coaxial wiring.

What did surprise me, during and after the system patrol, was the increase in general (wireless) spectral activity as compared to even just several years ago. So, I've shifted the topic of this article to just that - an examination of wireless spectral activity using an Aaronia test antenna and a Tektronix RSA306 real time spectrum analyzer. This report will consist almost entirely of screen shots from my test instrumentation, along with annotations and comments regarding activity found.

As I reflected recently on the dramatic increase in spectrum activity, I could not help thinking about the spring of 1973 when I acquired my first spectrum analyzer; a Tektronix 7L12 plug-in paired with a phosphorus storage mainframe. It was not unusual then to dial through large portions of the RF spectrum and viewing very little activity. In 2015, the opposite is true. It is now difficult to find open spectrum anywhere except in 'broadcast allocation bands' such as FM or ATSC off-air transmission. Where spectrum is allocated to a proliferation of newer services using sophisticated modulation techniques such as COFDM, however, transmission from a variety of locations *using the same spectrum* can be easily found.

And a lack of understanding of how new spectrum is allocated and whether channels overlap often causes confusion and problems. For example, most 'users' do not understand that the 13 channels allocated to the 2.4 GHz Wi-Fi system overlap, such that *only channels 1, 6 & 13 do not overlap each other*. And worse, it is not unusual to find many routers of similar signal strength all using the same channel or overlapping channels. Large, measurable reductions in overall throughput are typically experienced by local users who do not understand this basic problem. They only know that the speed they expect is not usually experienced.

DPX view. Most waveforms shown in this report use the Tektronix DPX view. This is a special spectrum analysis mode where the screen still depicts amplitude vs. frequency; however the *colors* indicate how often the signal is present over time (whether the signal is there all of the time or only a portion of the time). A user selected color temperature coding scale is employed. For example, the thermal color scale assigns colors such that red pixels indicate a signal that is present 100% of the time, while at the opposite end of the thermal scale blue to violet pixels indicate spectrum that is active approx. 10% of the time. And, the use of variable 'digital persistence' (1 sec to infinity) allows for the capture of very illusive signals for further analysis.

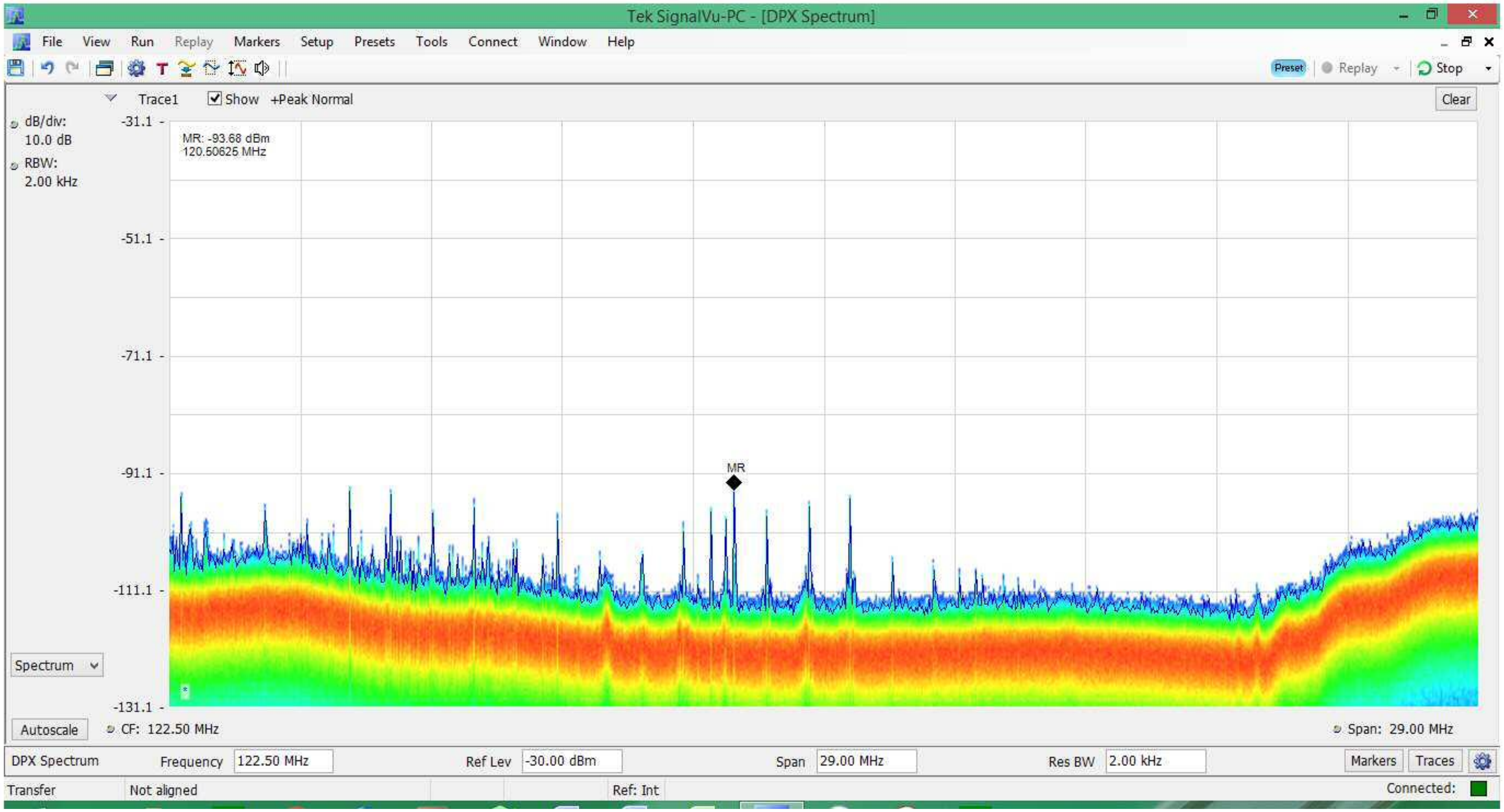
Finally, most of the signals in the following screen captures are fairly low in amplitude; however they are still sufficient in amplitude for the correct operation for most new communication system. All RF levels are shown in dBm. For conversion to dBmV (to compare with the RF signals found in an HFC cable plant), add 48.75 dB to the dBm reading to convert to dBmV. For example, the signal at the marker in the following waveform is at -93.7 dBm. That corresponds to - 44.8 dBmV (-93.7 +48.75); a very low level signal for a cable system but more than adequate for a narrow band communication system.

My review starts with the Aeronautical Band assignment from 108 to 137 MHz and proceeds on to higher frequency bands from there, ending with activity in the Wi-Fi allocation at 2.4 GHz.

Finally, the final waveforms shown (after the spectrum review process) are intended to further demonstrate the overall capabilities of the modern ‘software controlled’ digital spectrum analyzer, including analysis of an upstream 256-QAM signal that includes signal quality measurements (MER, EVM, etc.), a constellation diagram, and data coding tables of the demodulated signal. There really is very little limit to what can be measured with the modern RTA, and there are entry line models that are quite affordable; even for the small system operator or perhaps HAM enthusiast with an adequate test equipment budget.

Now onto some screen captures.

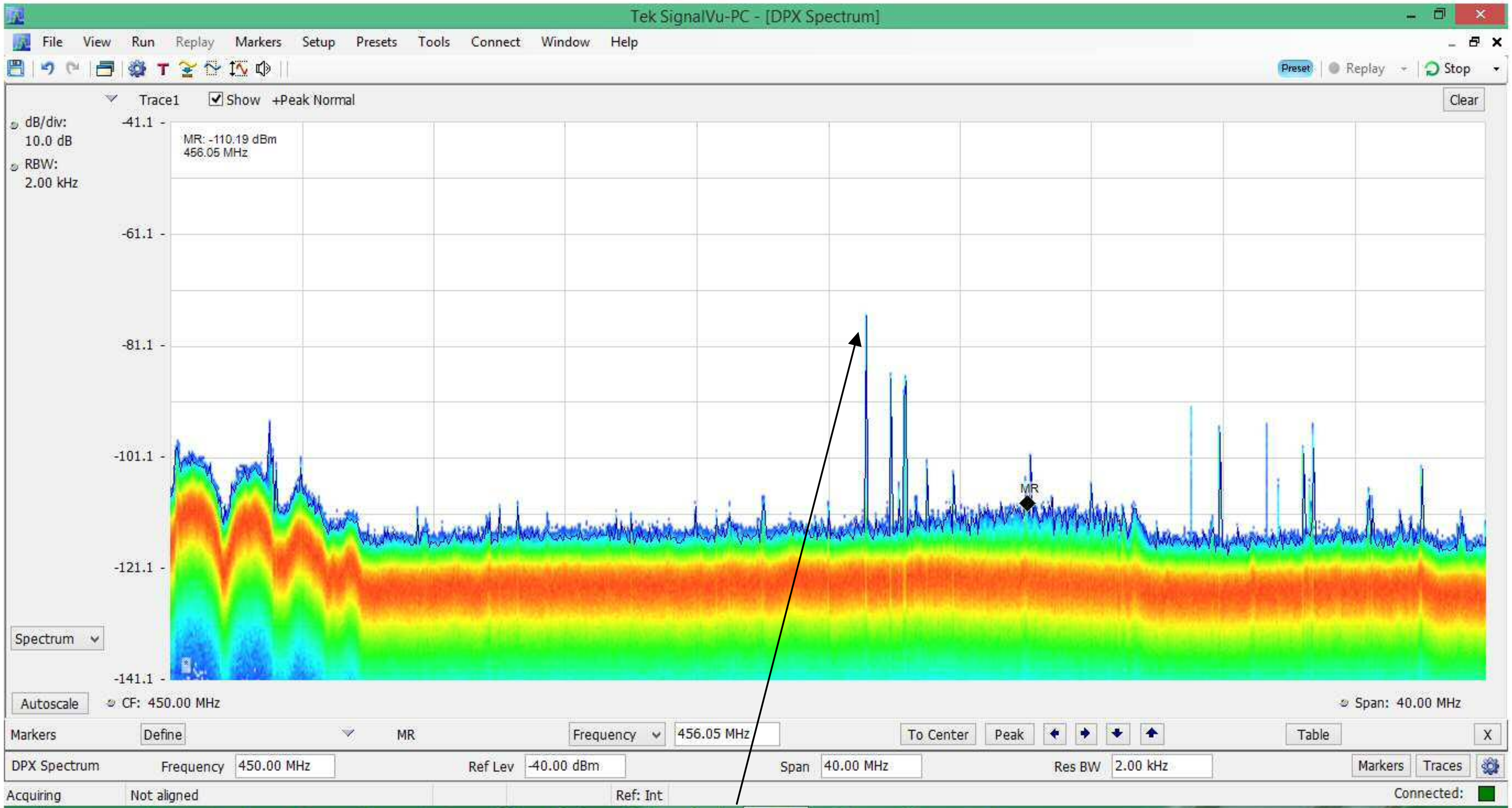
108 to 137 MHz Aeronautical Band Spectrum. Add 48.75 to convert RF levels from dBm to dBmV.



Aaronia 4060 antenna response is not flat below 400 MHz, however this waveform still serves to illustrate overall spectrum activity.

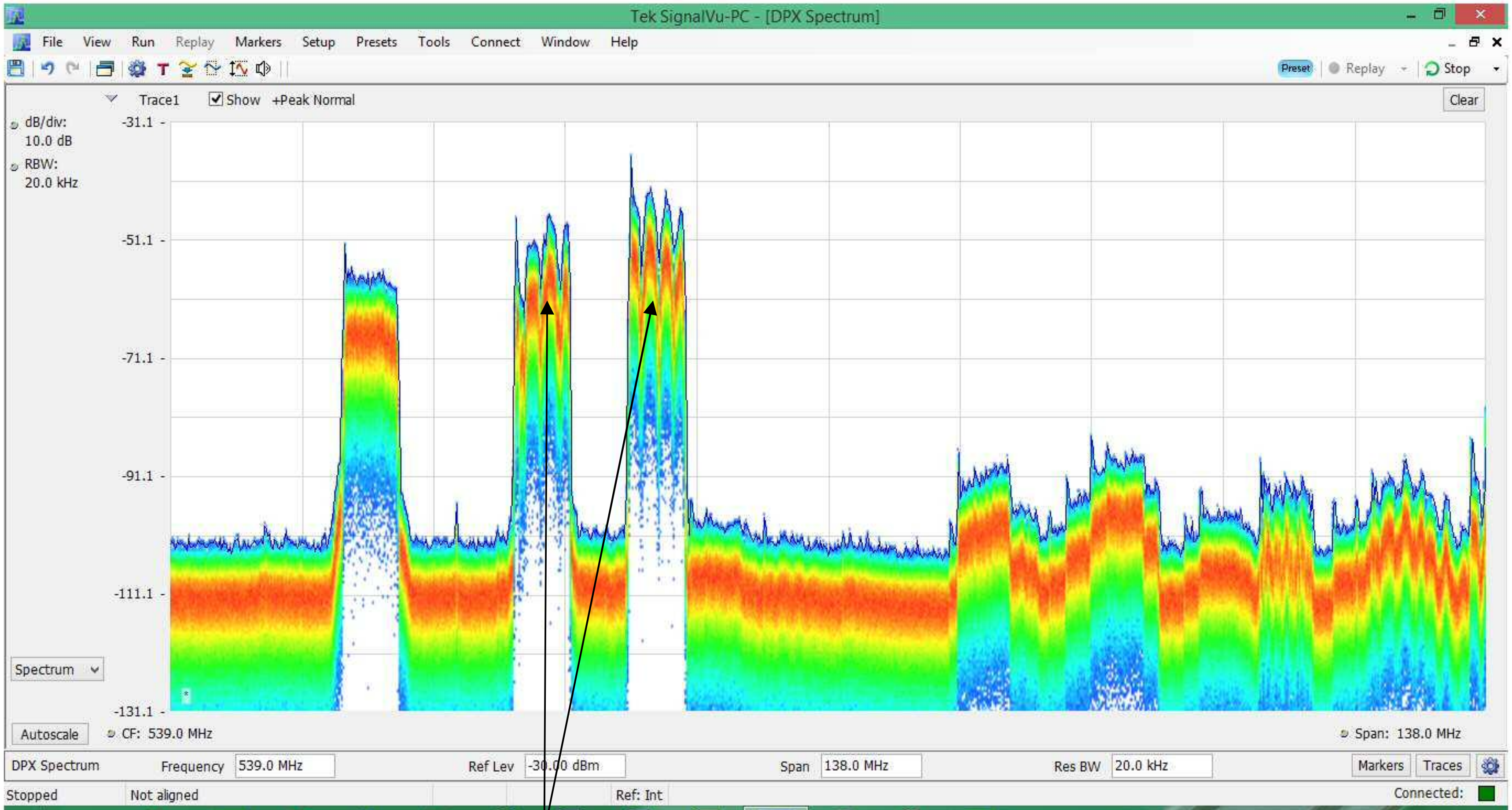
The highest amplitude carrier is at 120.60625 MHz, -93.68 dBm (-44.9 dBmV)

430 to 470 MHz spectrum view for HAM and Mobile Radio Service Spectrum



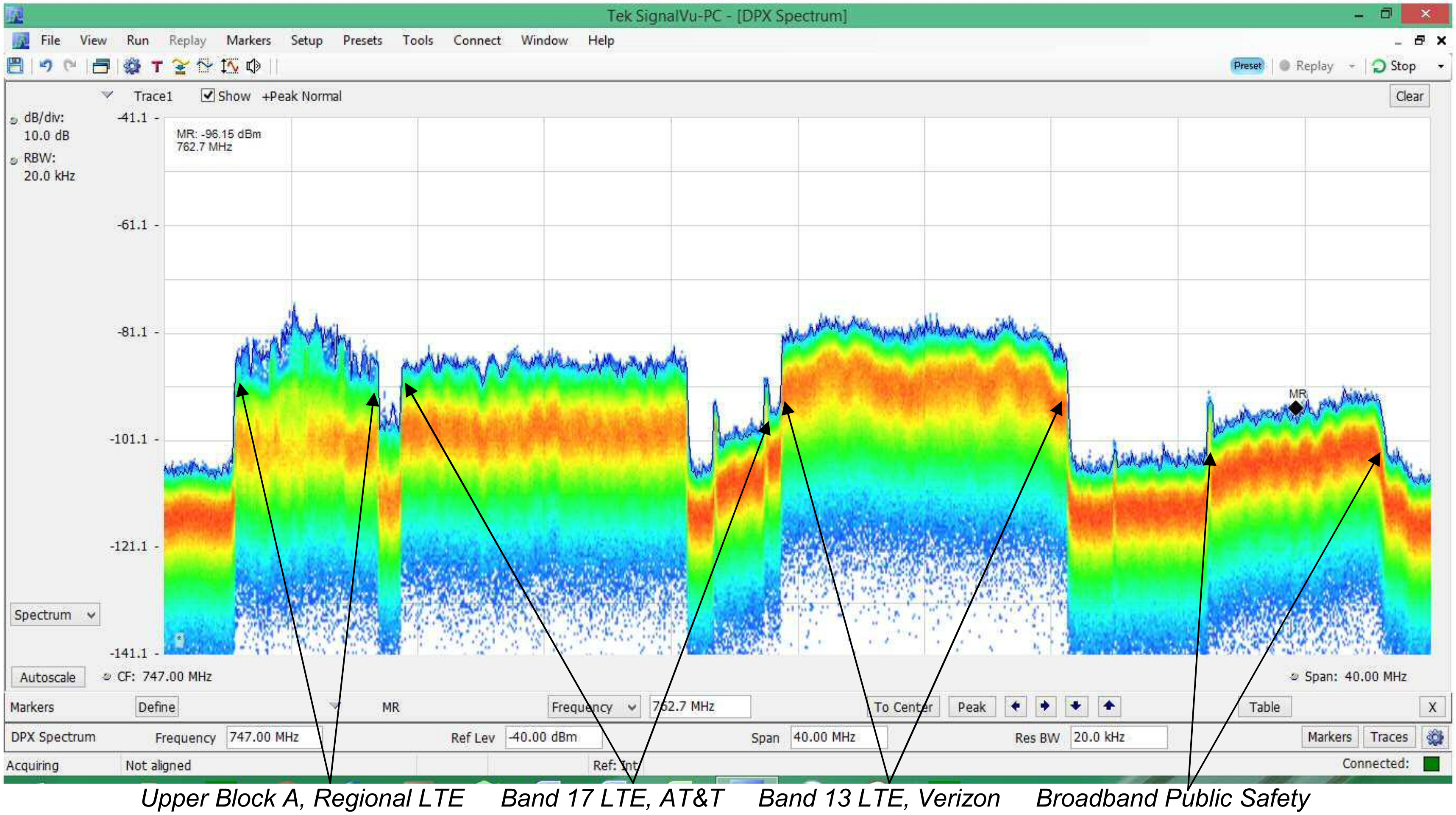
450 to 470 MHz is allocated to UHF Business Band use. The highest RF level carrier is at 451.15 MHz, -73.6 dBm (-24.85 dBmV).

UHF ATSC (8-VSB) Activity, 470 to 698 MHz (UHF Channels 14 through 51).

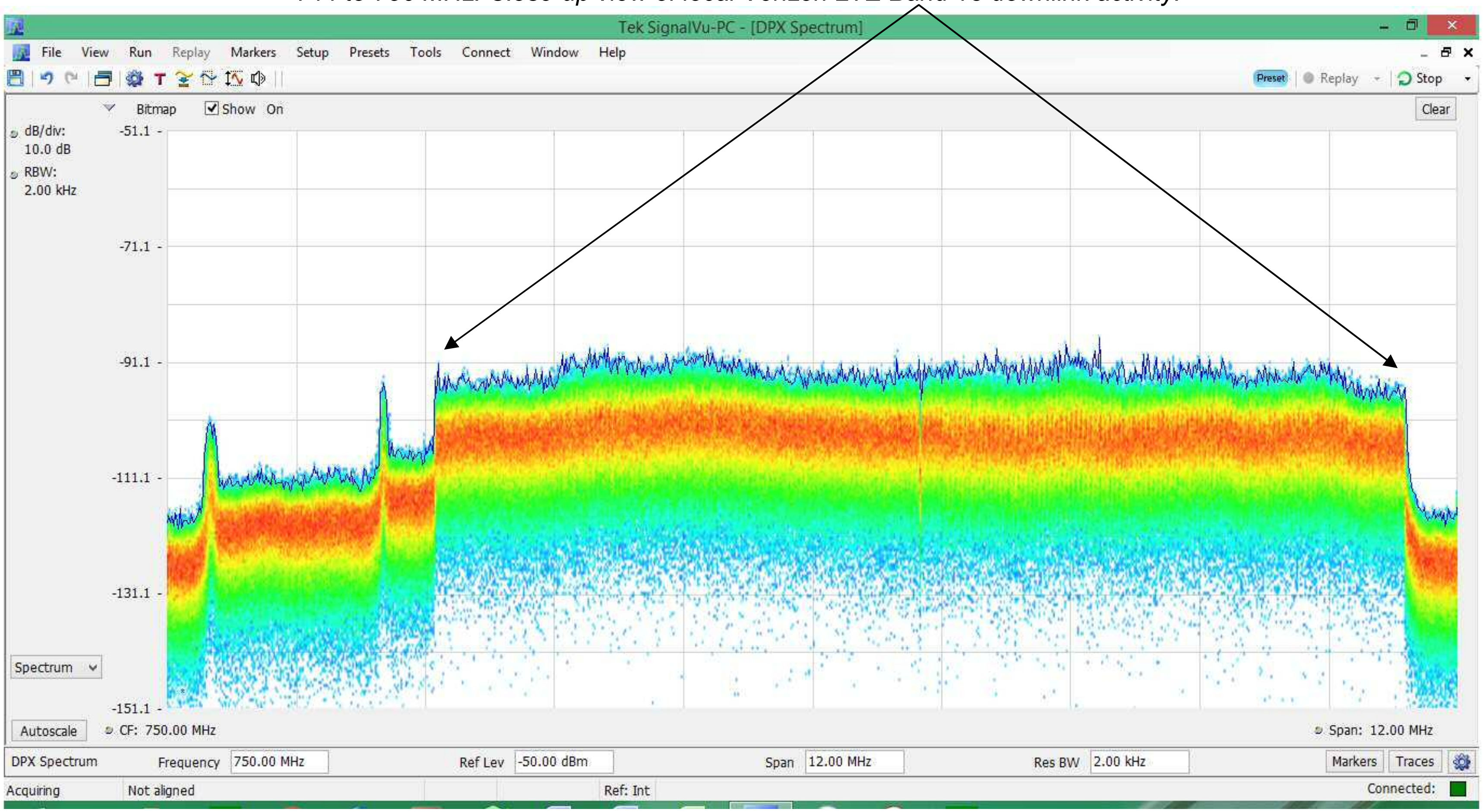


Response of these 8-VSB haystacks is poor, signal reflections are present from a local metal structure.
More 8-VSB waveforms are analyzed towards the end of this report.

Spectrum capture from 727 to 767 MHz. Spectral allocations are detailed below.

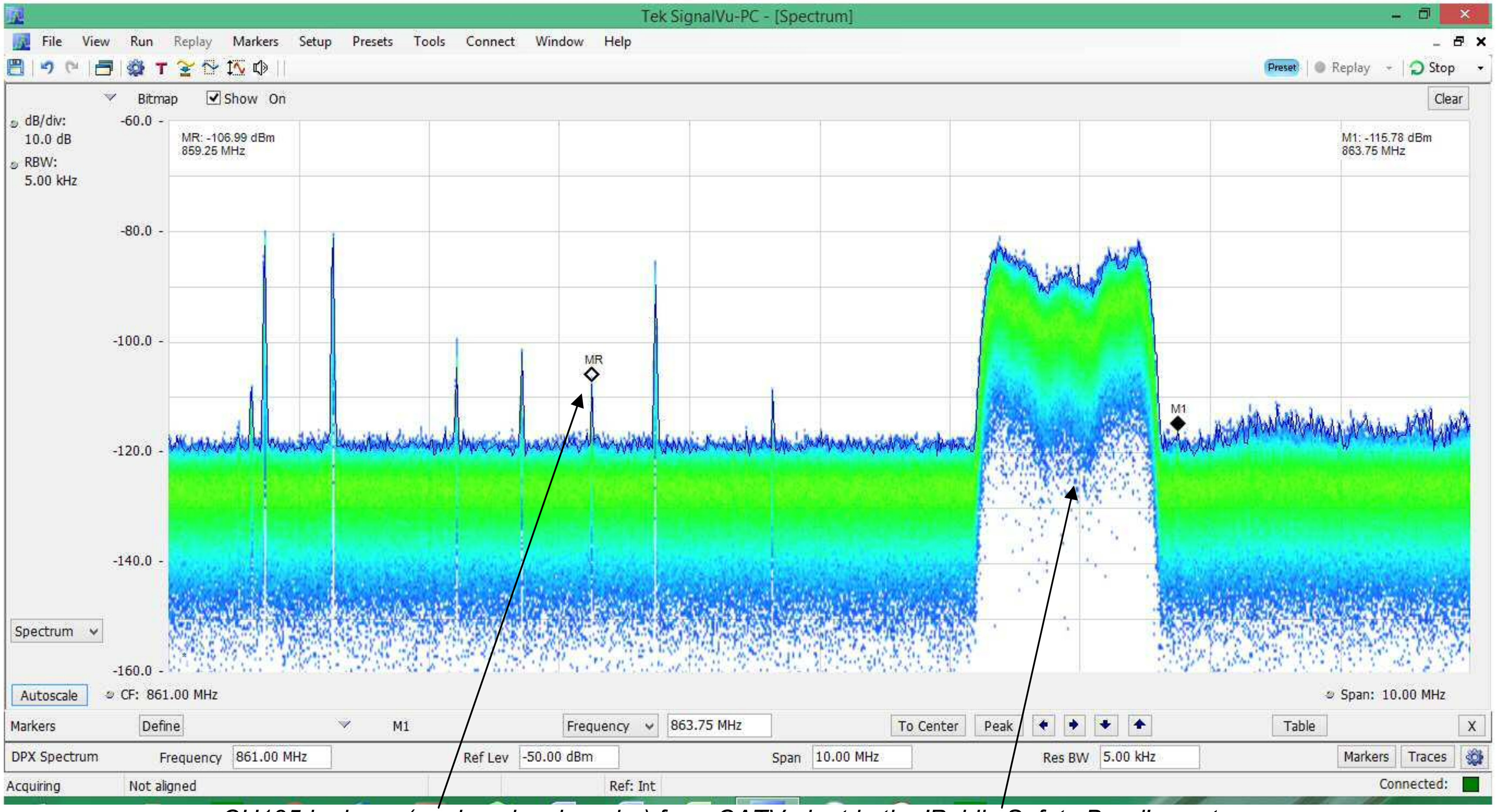


744 to 756 MHz. Close-up view of local Verizon LTE Band 13 downlink activity.



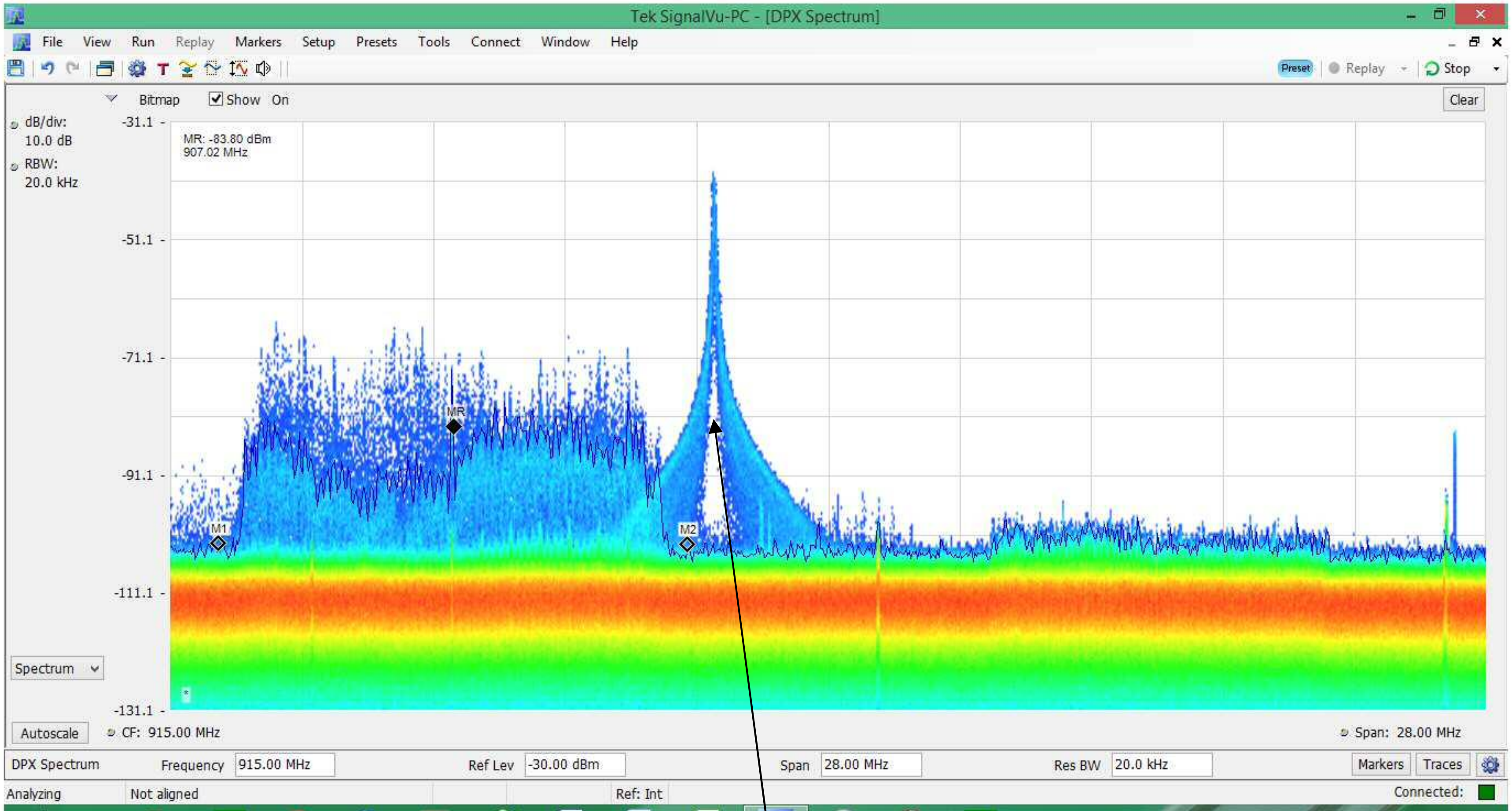
This spectrum overlaps cable CEA/EIA channels 116 & 117. See next waveform for an example in the 860 MHz spectrum.

Spectrum capture from 856 to 866 MHz: 'Public Safety' and Commercial 2-way Band.



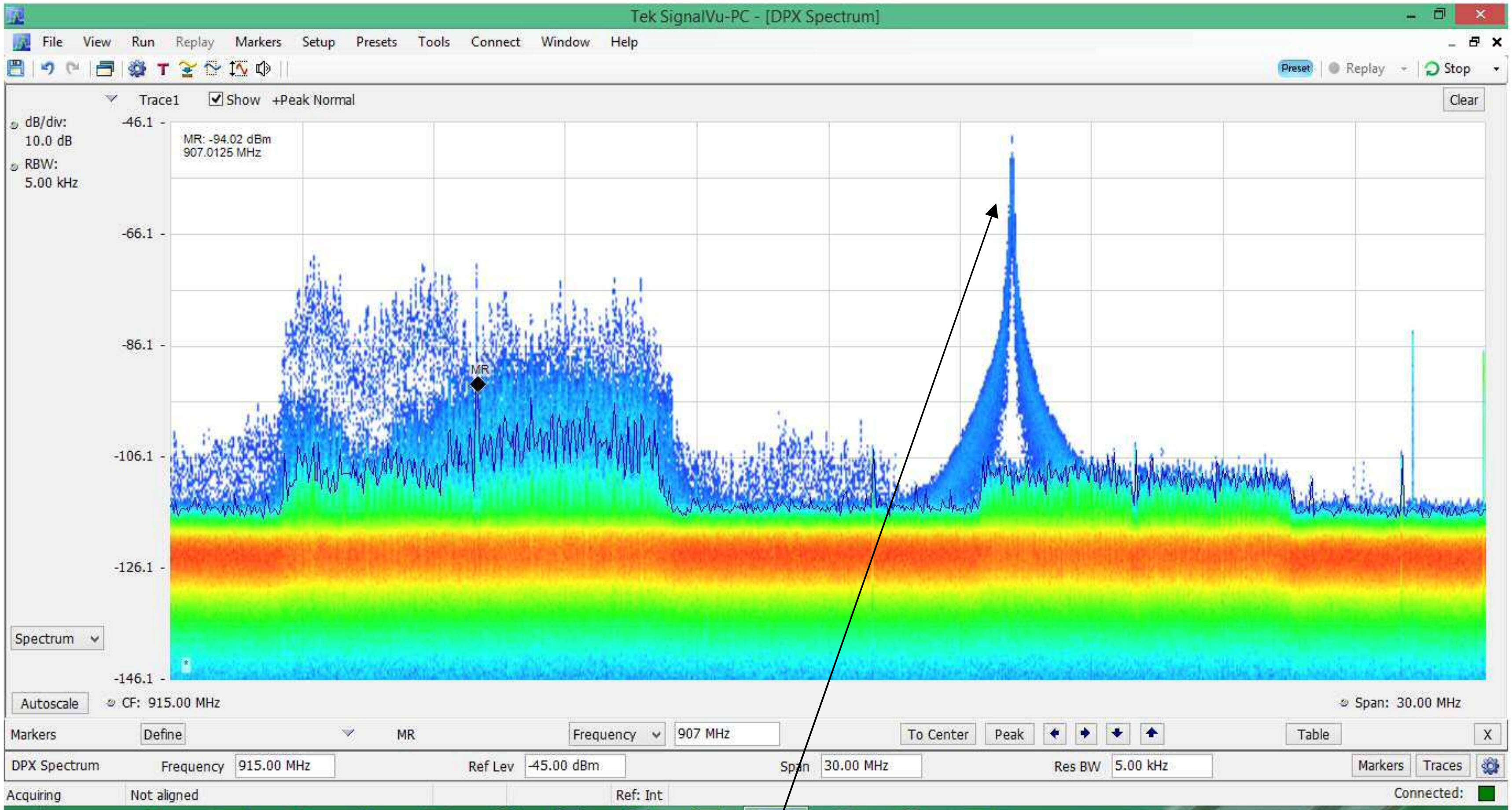
CH135 leakage (analog visual carrier) from CATV plant in the 'Public Safety Band' spectrum.
The RF level of the CH135 visual carrier in dBm converts to approx. 38 µvolts/mtr
at 3 meters, with the FCC limit for this band at 150 µvolts/mtr at 3 meters.

HAM 33cm band – 902 to 928 MHz



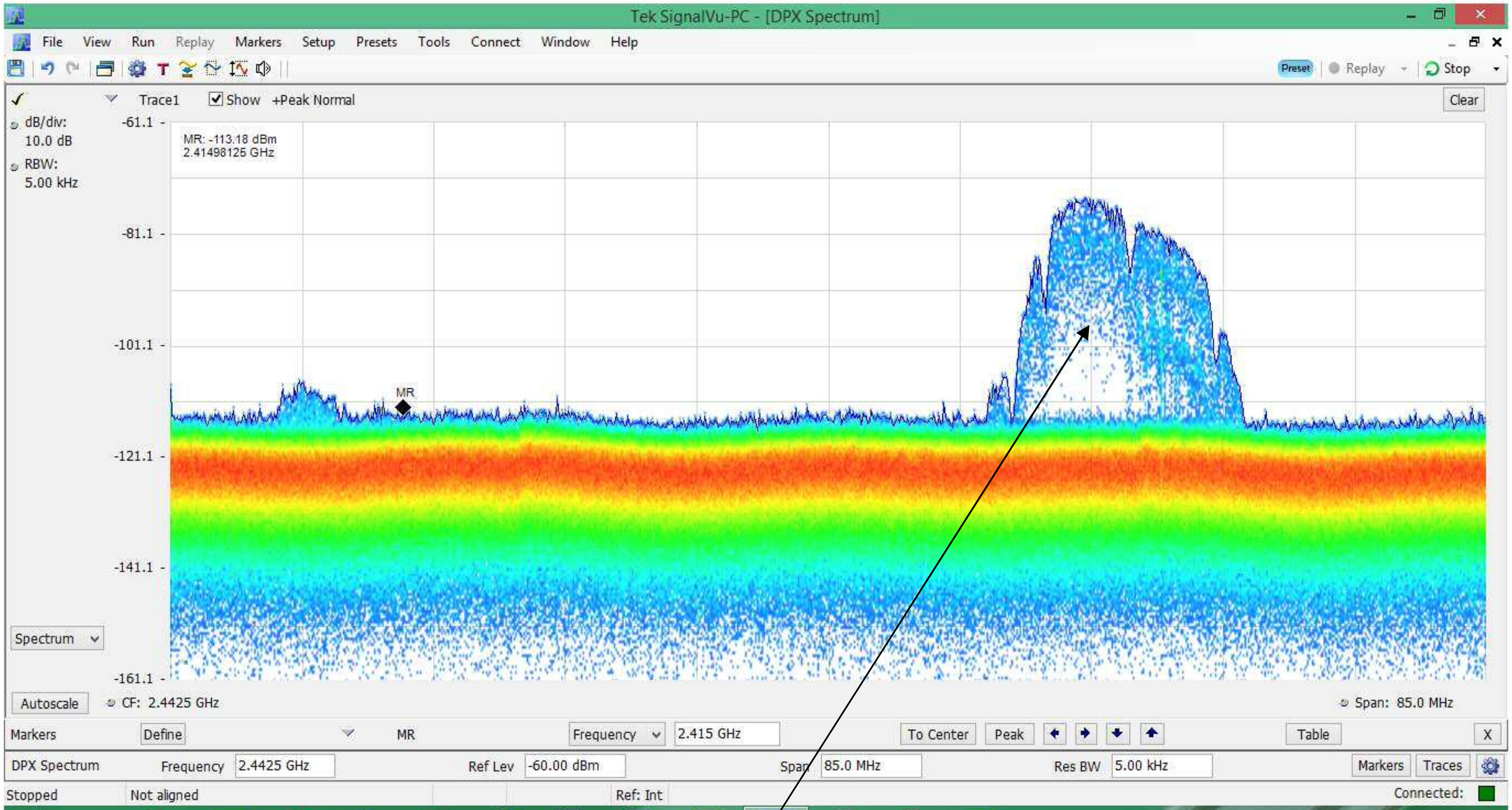
An unknown higher level carrier was captured that was intermittent in nature and frequency agile. See next waveform.

HAM 33cm band – 902 to 928 MHz



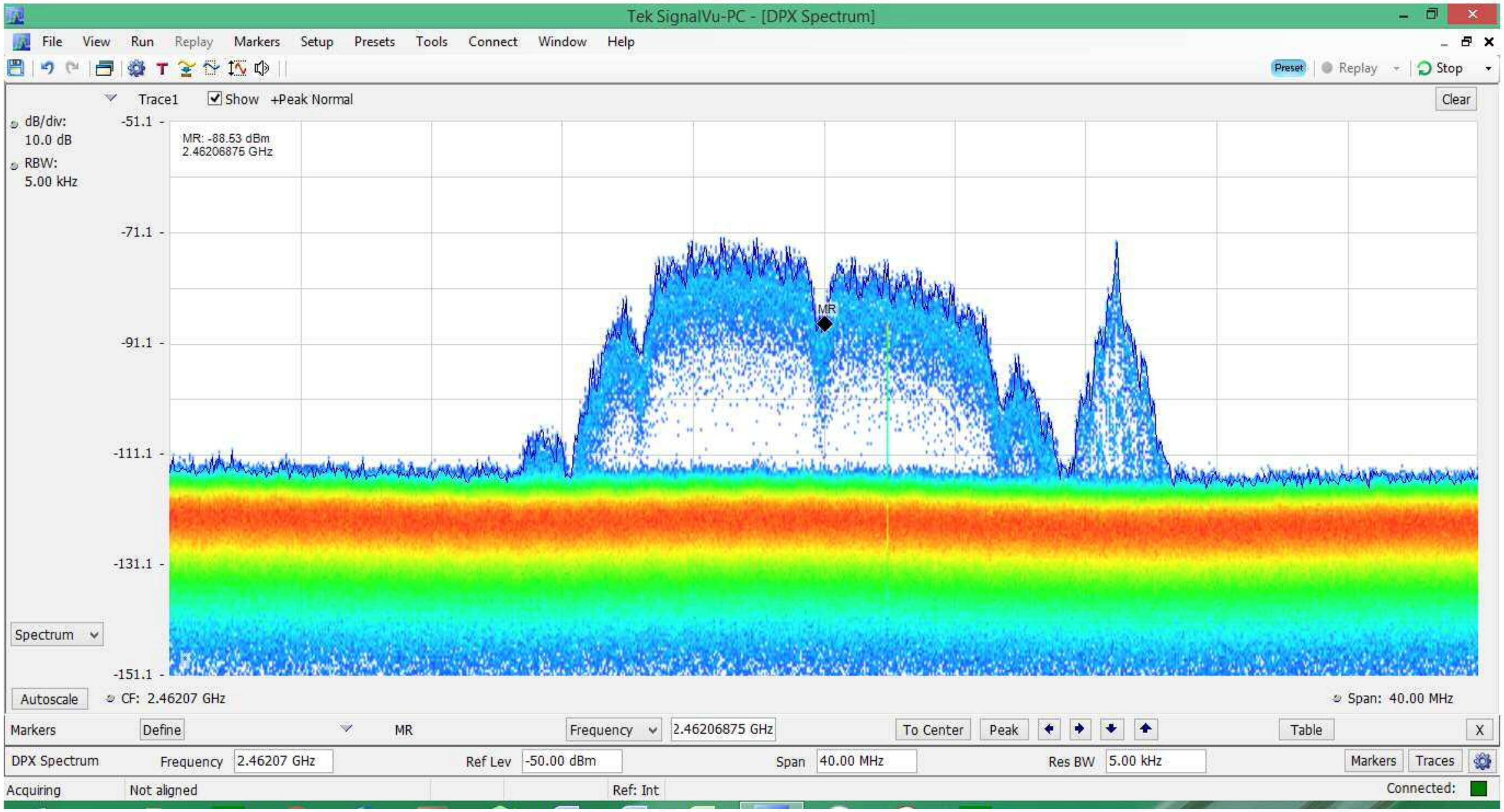
Note that the agile carrier has now jumped to a higher frequency, while still at the same approximate RF amplitude.

Entire 2.4 GHz ISM Band: 2.400 to 2.4485 GHz



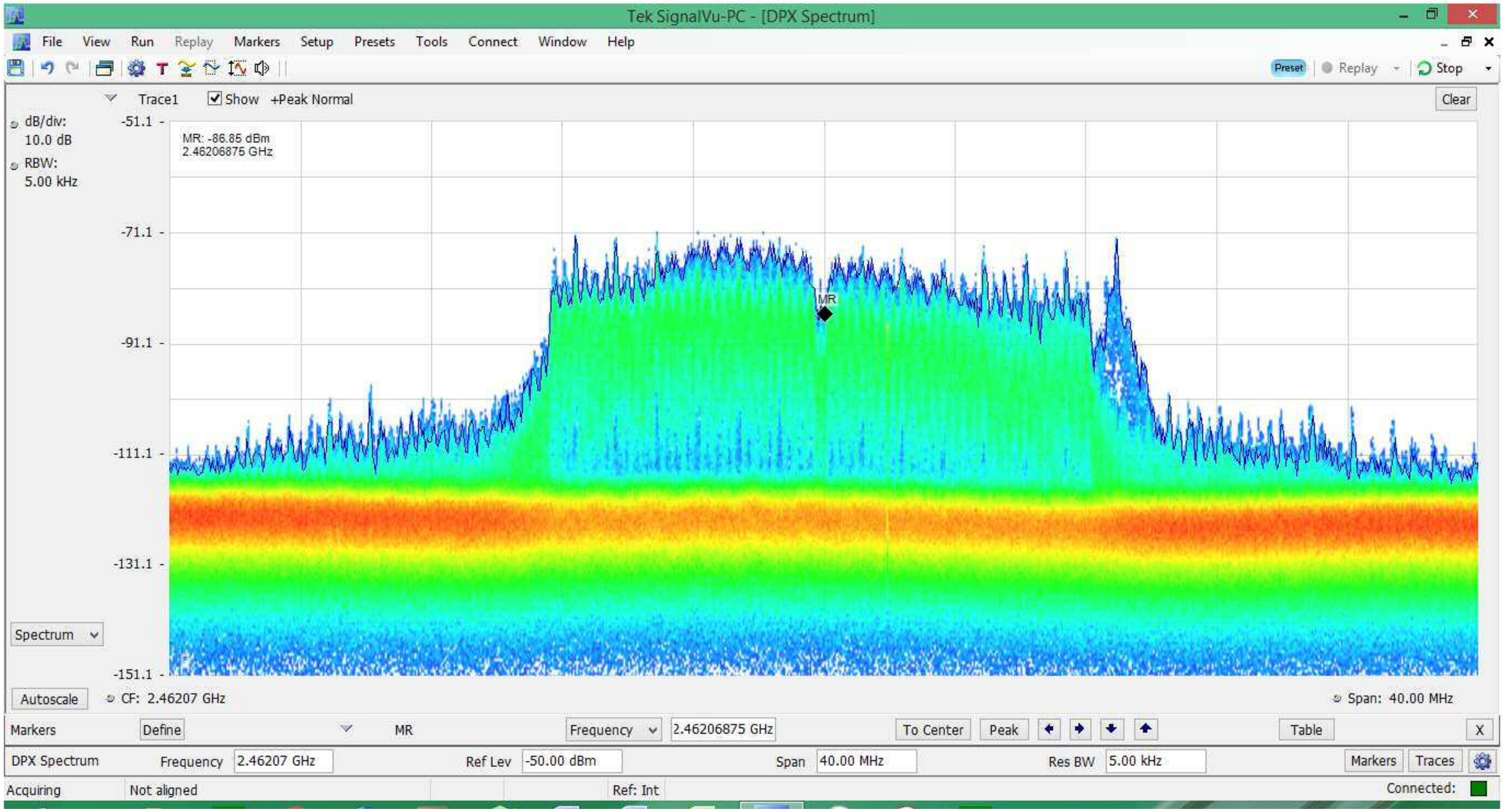
Local Wi-Fi router activity.

Spectrum capture from 2.442 to 2.482 GHz: Local Wi-Fi Spectrum Only:



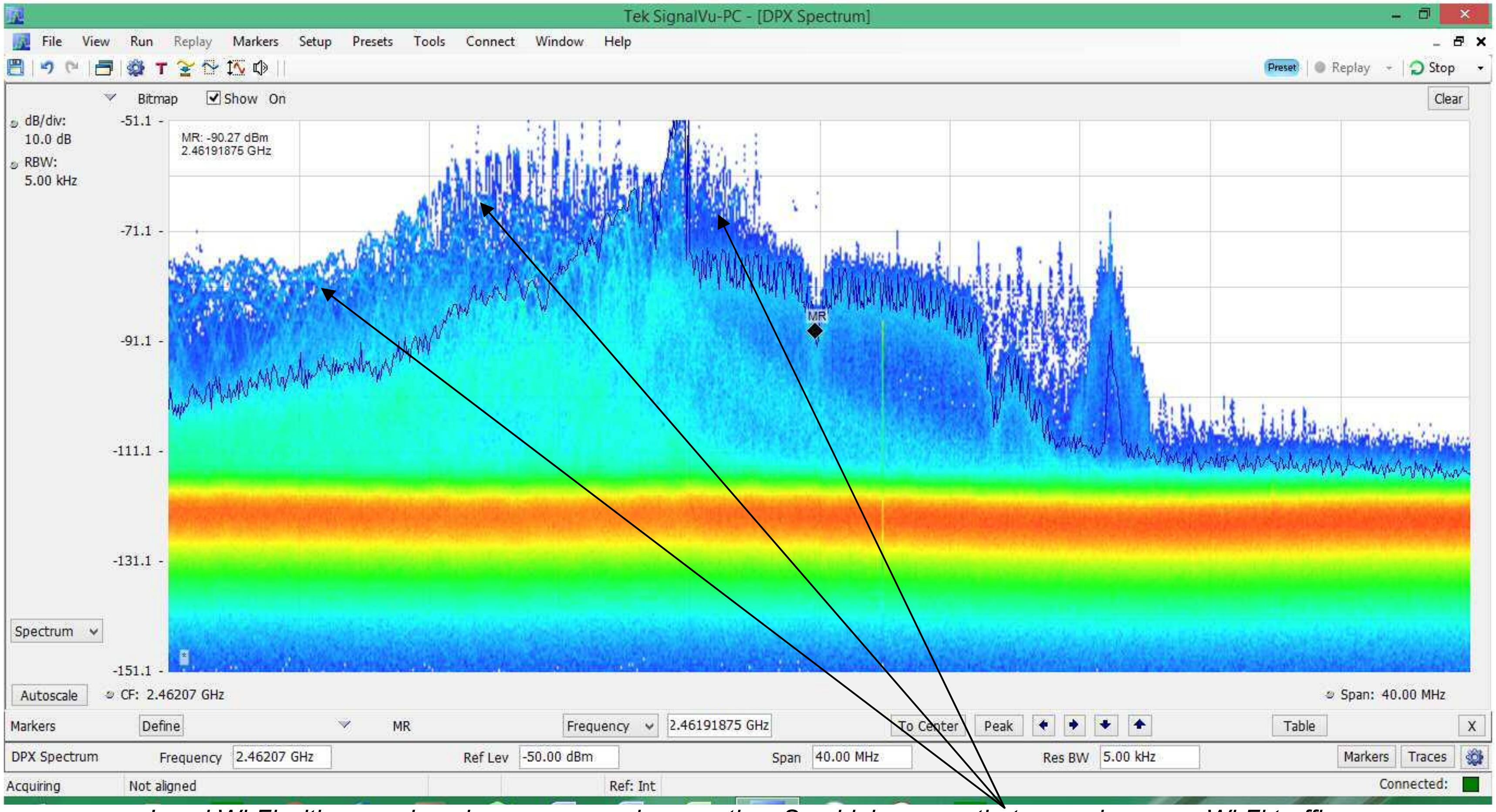
Local router transmissions only, no laptop traffic.

Spectrum capture from 2.442 to 2.482 GHz: Local Wi-Fi Spectrum Only:



Router plus laptop transmissions during large file transfer

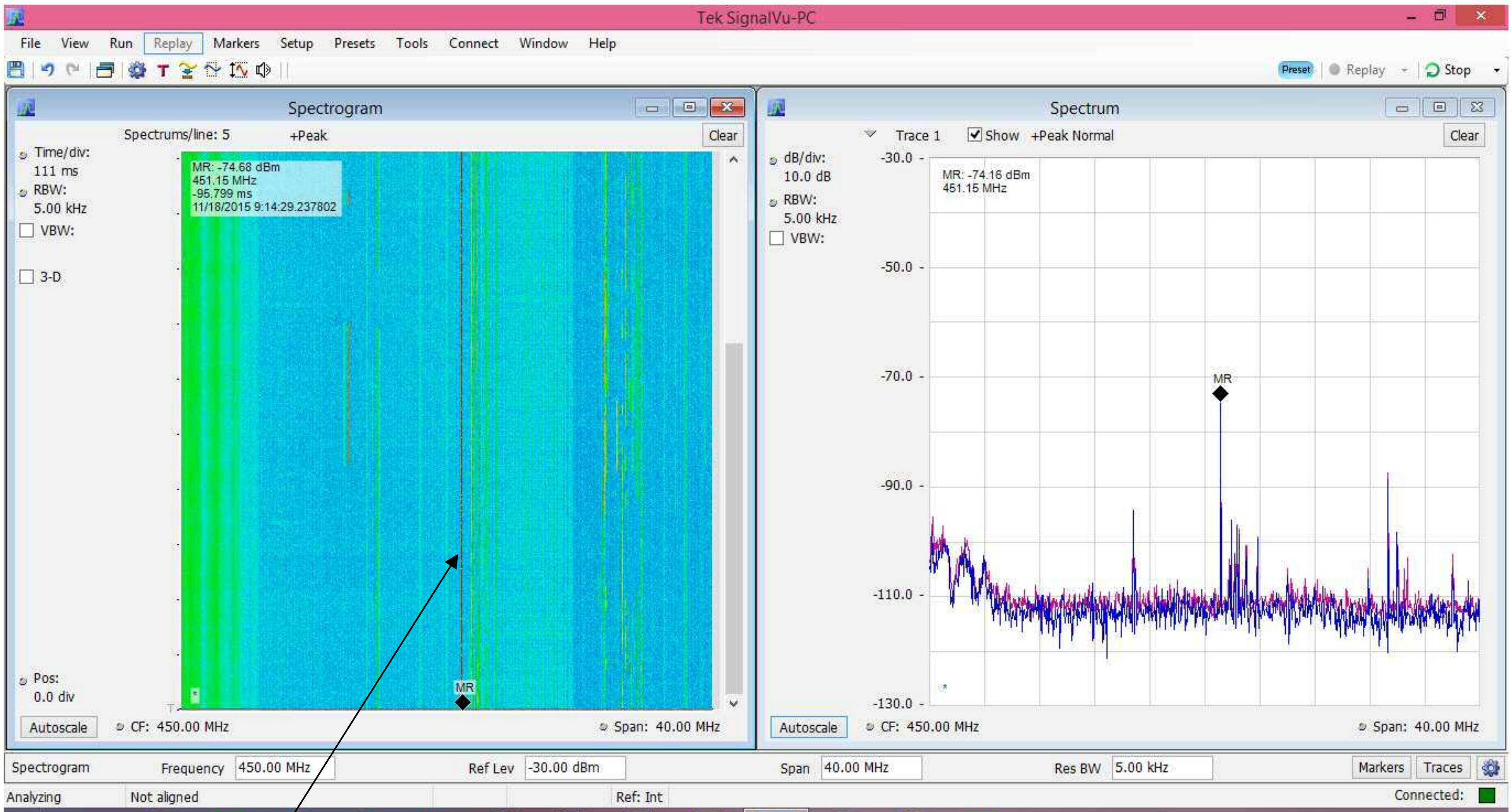
Spectrum capture from 2.442 to 2.482 GHz. Wi-Fi plus Microwave Oven.



Local Wi-Fi with a nearby microwave oven in operation. See high energy that spreads across Wi-Fi traffic.

The remaining waveforms explore some of the more advanced features of the modern software controlled real-time analyzer.

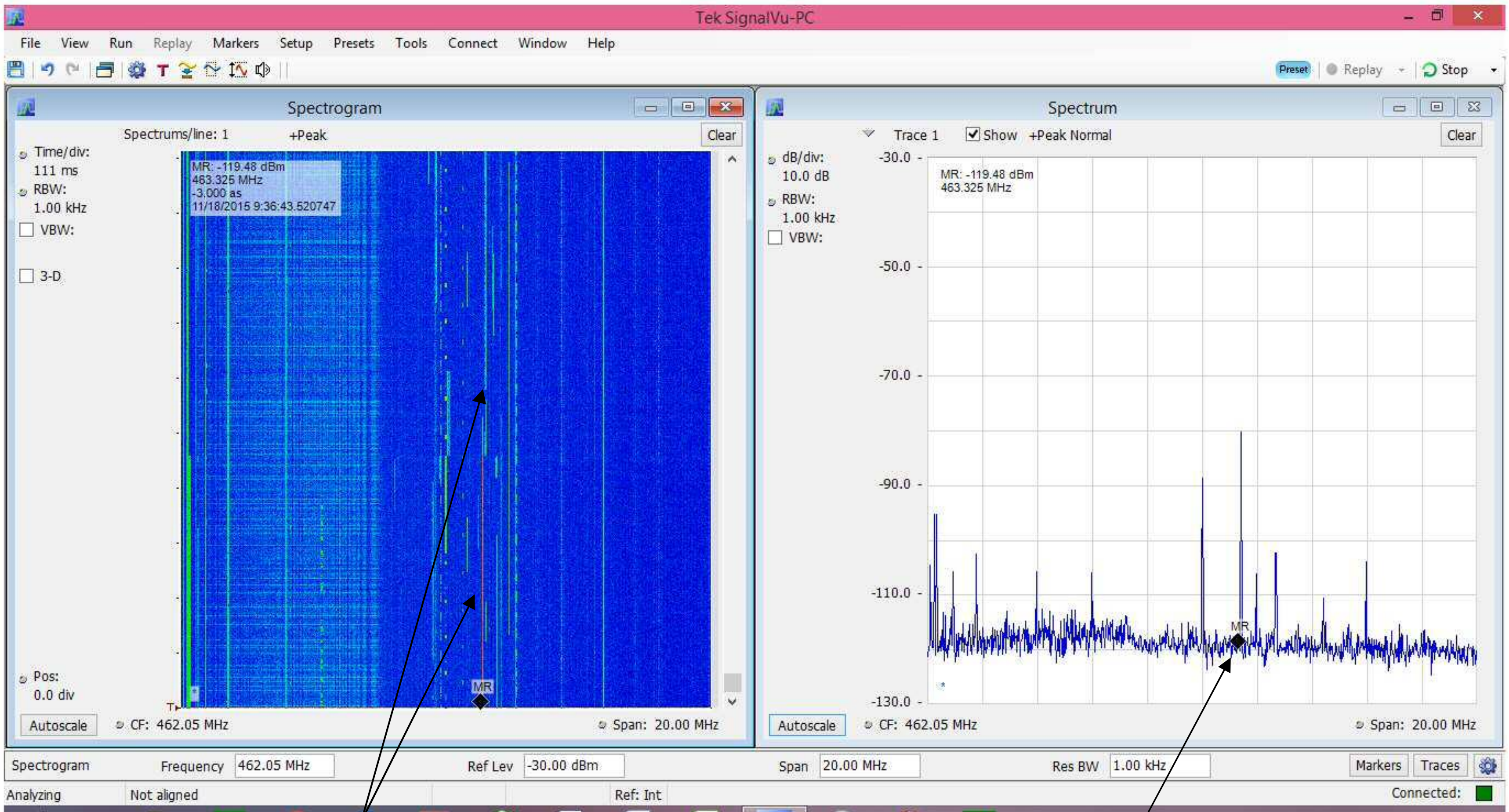
Spectrum Capture from 430 to 470 MHz: Public Service Band



Note this signal (at the marker) is present the entire time. This spectrum capture explores some of the capabilities of the modern, software drive RTA (real-time analyzer). The above split-screen view shows a 'waterfall view' on the left and a standard spectrum analyzer view on the right. The waterfall view shows the same spectrum as on the right, however it depicts time (Y axis) vs. frequency (X axis) vs. signal strength (colors). The waterfall (spectrogram) recording can be halted at any point, with the capability to 'step' back in time (through data stored) to view signals on the right analyzer side as they come and go.

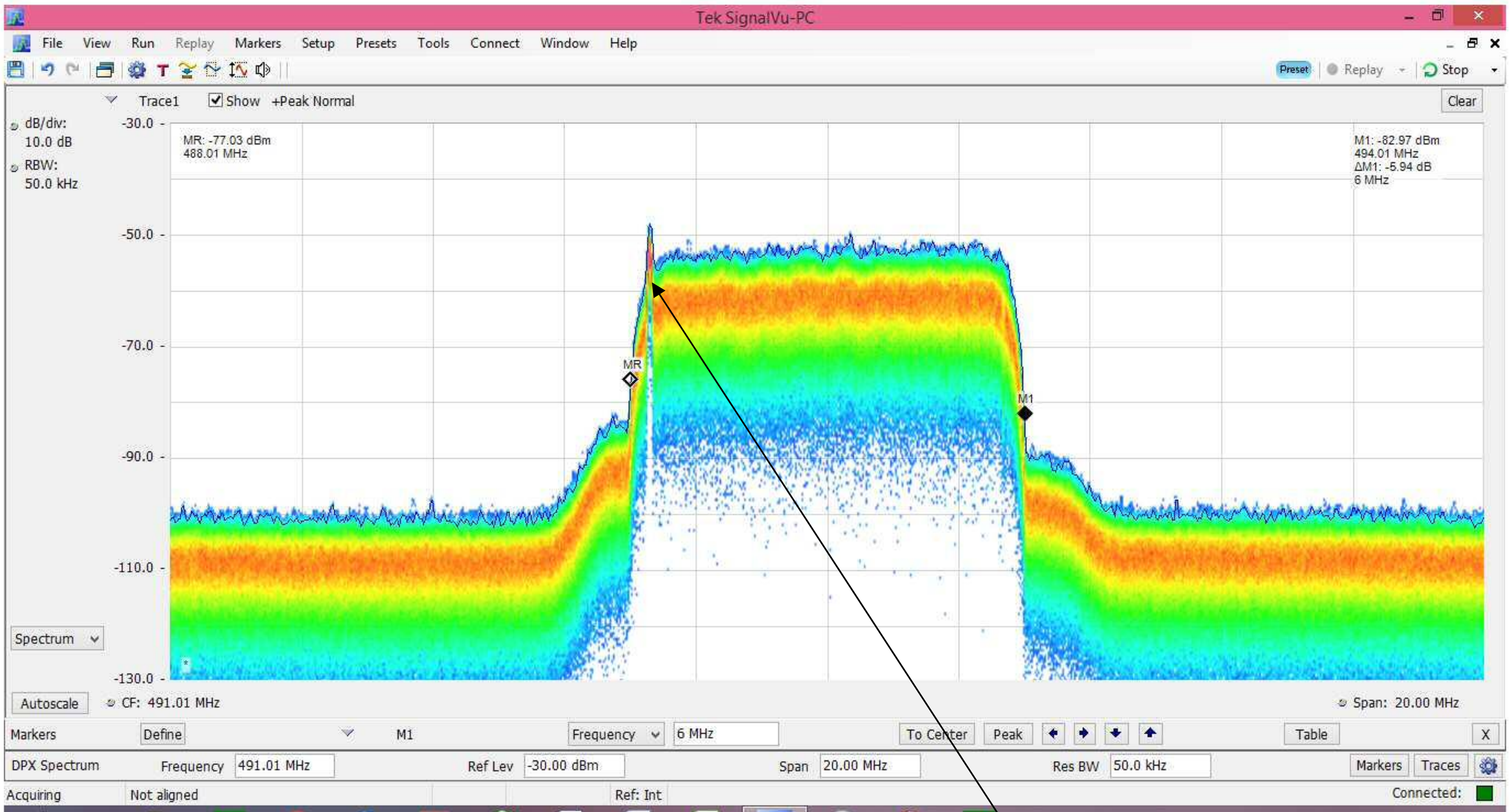
Now view the screenshot on the next page.

Spectrum Capture from 430 to 470 MHz: Public Service Band



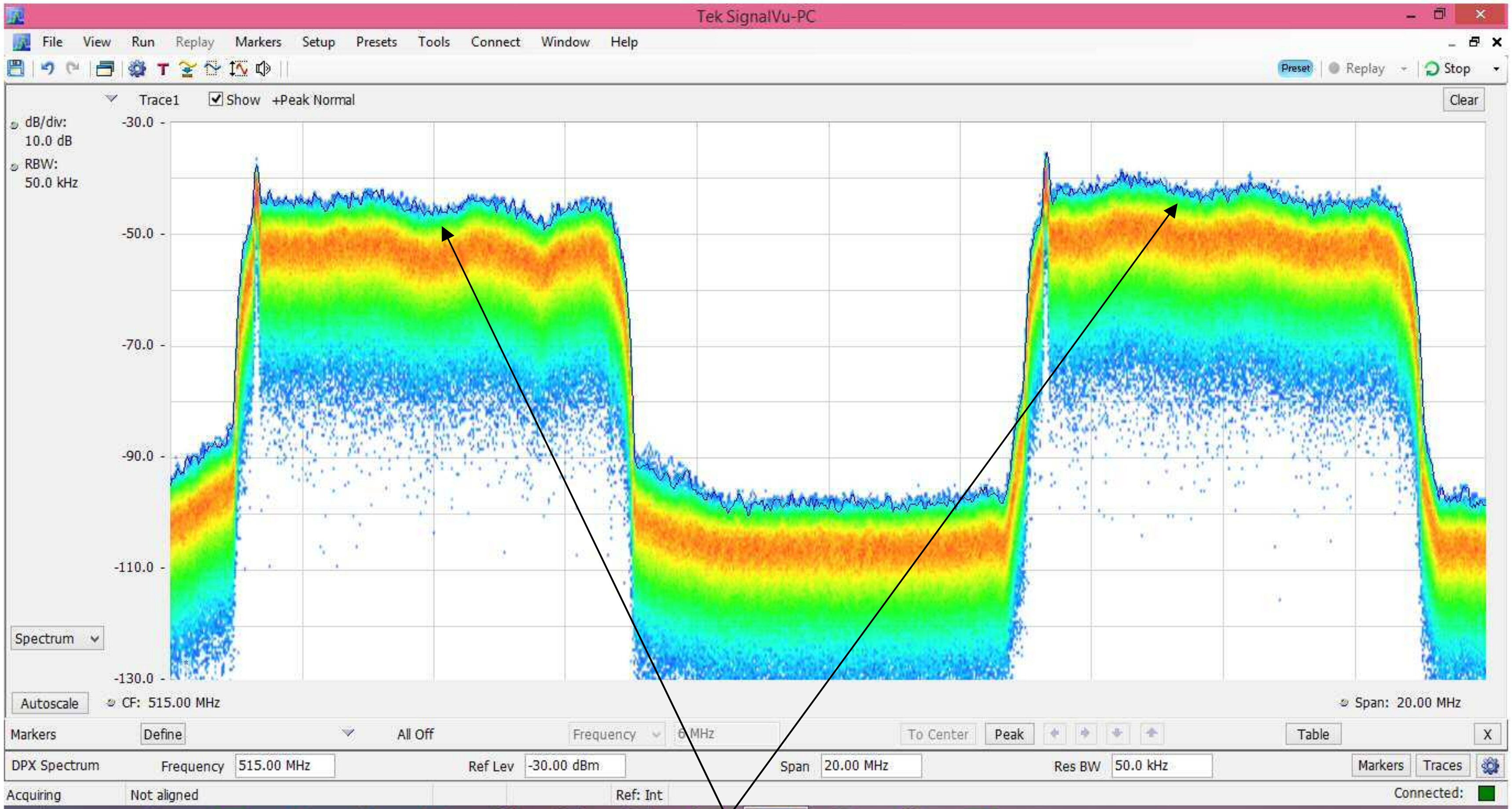
Note that the signal at the marker is now intermittent; it is present at the bottom of the waterfall but not at the top. Time flows from top to bottom in this Spectrogram (some analyzer brands have it flow the opposite direction).The top (most recent) portion of the spectrogram shows the signal is gone, as also indicated on the spectrum analyzer view at the marker. Also note many other signals on the left are intermittent in nature, and some have a very definite periodicity.

A UHF ATSC Off-Air High Definition (8-VSB) Haystack: 481 to 501 MHz. DPX mode is in use on the analyzer.



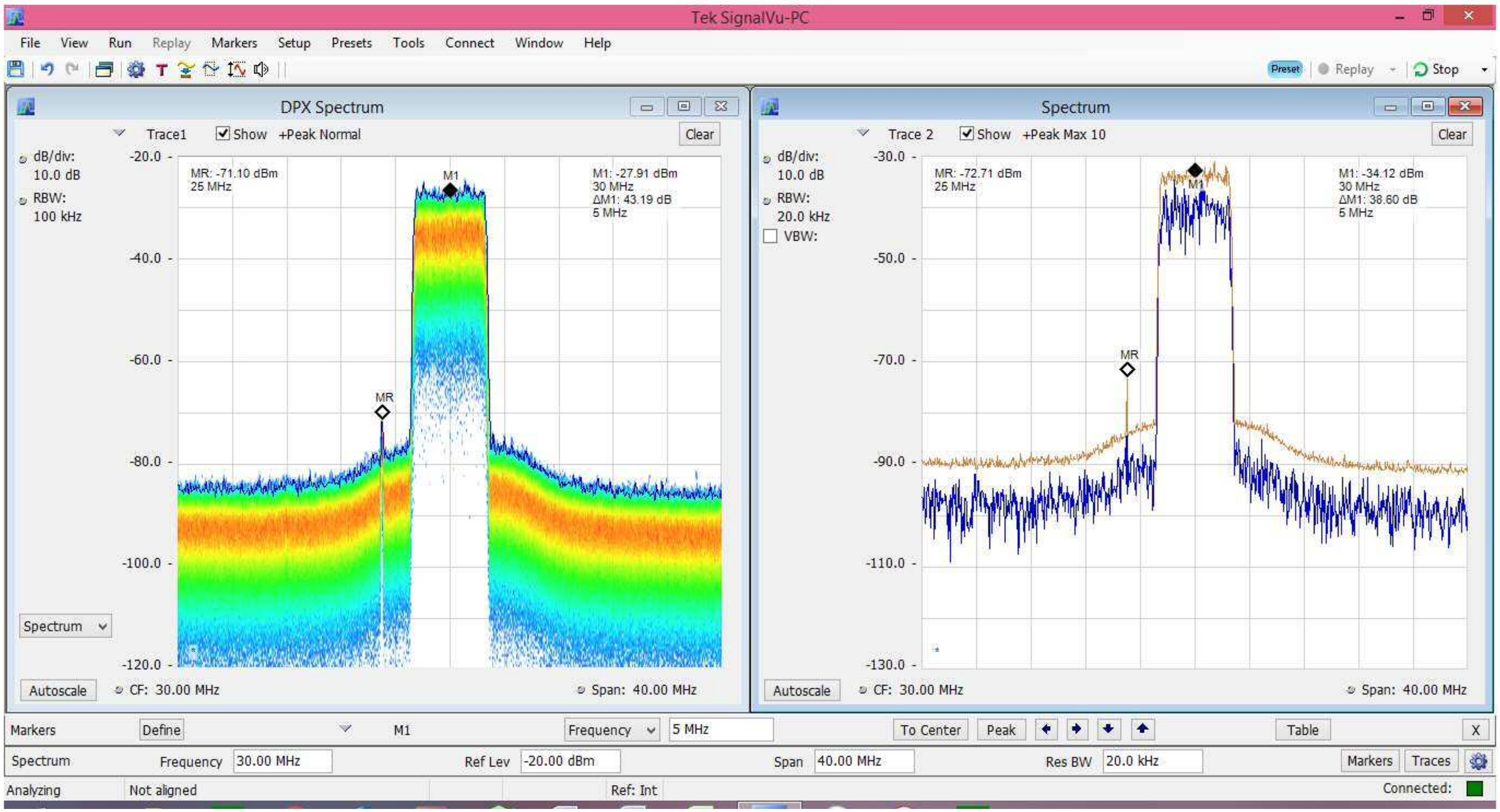
Note the flat haystack for UHF Channel 17, with a clearly defined pilot carrier on the leading edge.
Markers note the assigned 6 MHz bandwidth for this channel. Spectral energy is obviously spreading beyond the assigned BW; however it is reduced in amplitude and there are no adjacent channels to be interfered with.

505 to 525 MHz. Two UHF ATSC/8-VSB Haystacks (UHF CH20 & CH22).



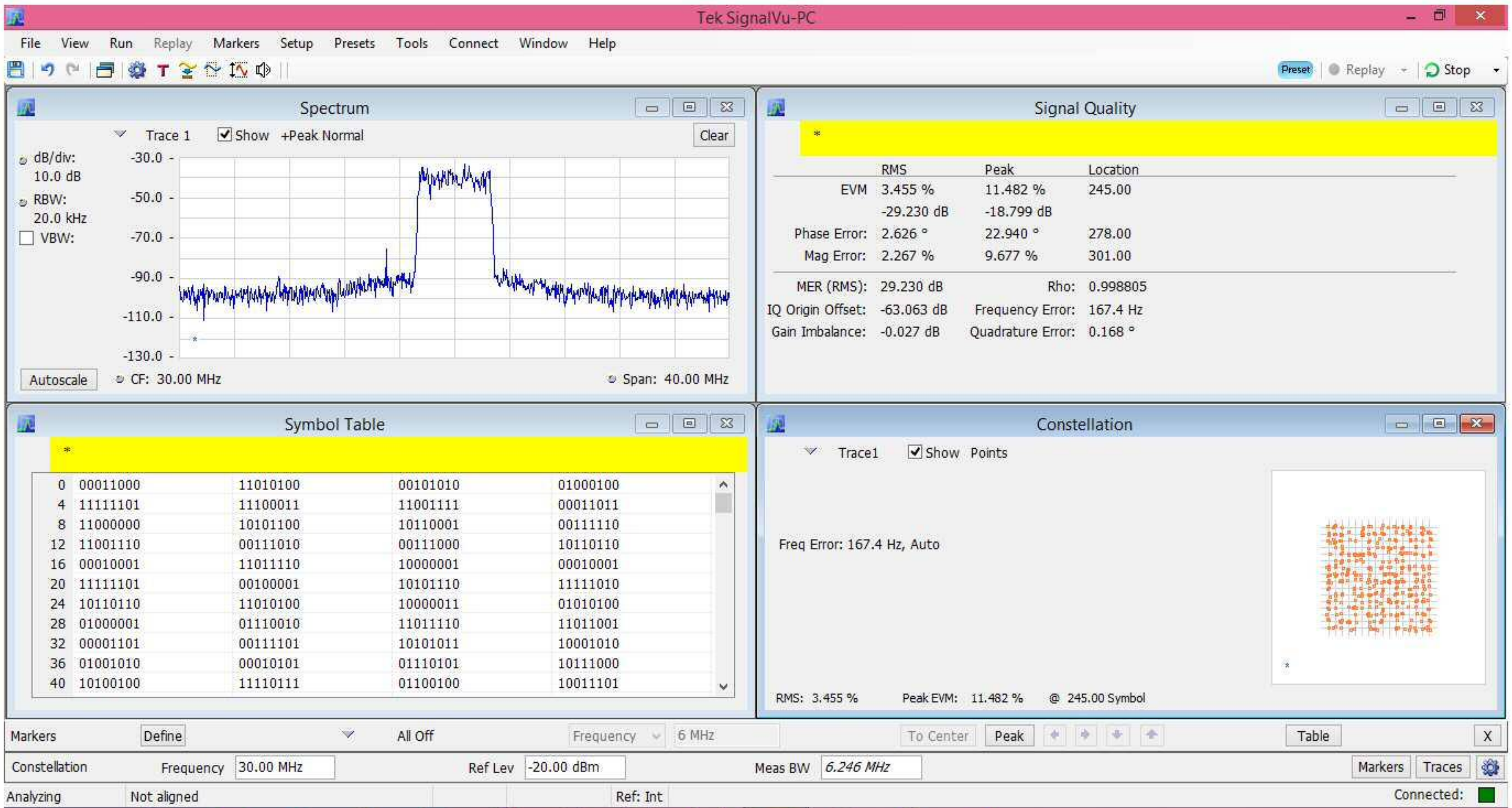
These haystacks are not performing as well, with a lack of flatness on the haystack due to signal reflections from a local metal structure. Overall performance for these channels would still be quite good.

Spectrum capture from 10 to 50 MHz measuring an upstream 256-QAM carrier.



Both views, DPX on the left and standard spectrum analyzer on the right, illustrate power level and flatness of the QAM carrier.
Note that there is a spur (beat) present just below the QAM carrier at 25.00 MHz.
The markers indicate total RF delta between the two carriers is 38.6 dB.

Detailed measurement of the upstream 256-QAM carrier, including Spectrum, Signal Quality, Symbol Table & Constellation.



The constellation diagram would appear to have a problem, but in reality the constellation diagram was fine. The sampling method employed by the RTA and the use of the Symbol Table test makes constellation points appear to jump around as various decision points are analyzed and the Symbol Table is updated.

Conclusion
In conclusion, the screen shots in this report were taken during measurements recorded both in the field and at my office during several measurement sessions. I chose these particular screen captures because I felt they:

- Best illustrated spectral activity in areas that would be of interest to the cable operator.
- To better demonstrate the capabilities of the modern RTA.

The modern software-driven real-time spectrum analyzer has become affordable for most and offers features not available with other analyzers. To be sure, there are some limitations found in the lower-priced units, but use of external filtering and practice with the unit serve to limit these limitations.

If you'd like further information on the unit I'm using, feel free to contact me at the following email address. I don't sell these units, but rather simply seek to raise awareness within the industry as to their availability and many advantages.

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Best regards and Happy Holidays.

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Cablesoft Engineering