CCBE 2023
Using Maxxcasting to Solve FM Coverage Issues in a Congested Urban Market (or any other)

FRANÇOIS O. GAUTHIER, ING. P. ENG

WWW.OCTAVECOM.COM

About Geo Broadcast Solutions

GeoBroadcast Solutions was formed in 2011 to develop the ZoneCasting™ Geo-Targeting platform. This platform has been successfully tested under special FCC authorization. There is now a Notice of Proposed Rule Making (NPRM) at the FCC which would allow Geo-Targeted separation of the main channel audio of an FM radio station to its listeners. This ability to split an FM signal into local "zones" has gathered exceptional industry support. Out of this development effort came MaxxCasting™, which increases signal quality, PPM watermark decoding, and allows geographic targeting and fencing of radio screen advertising. It is successfully deployed and operational in many markets and growing rapidly.

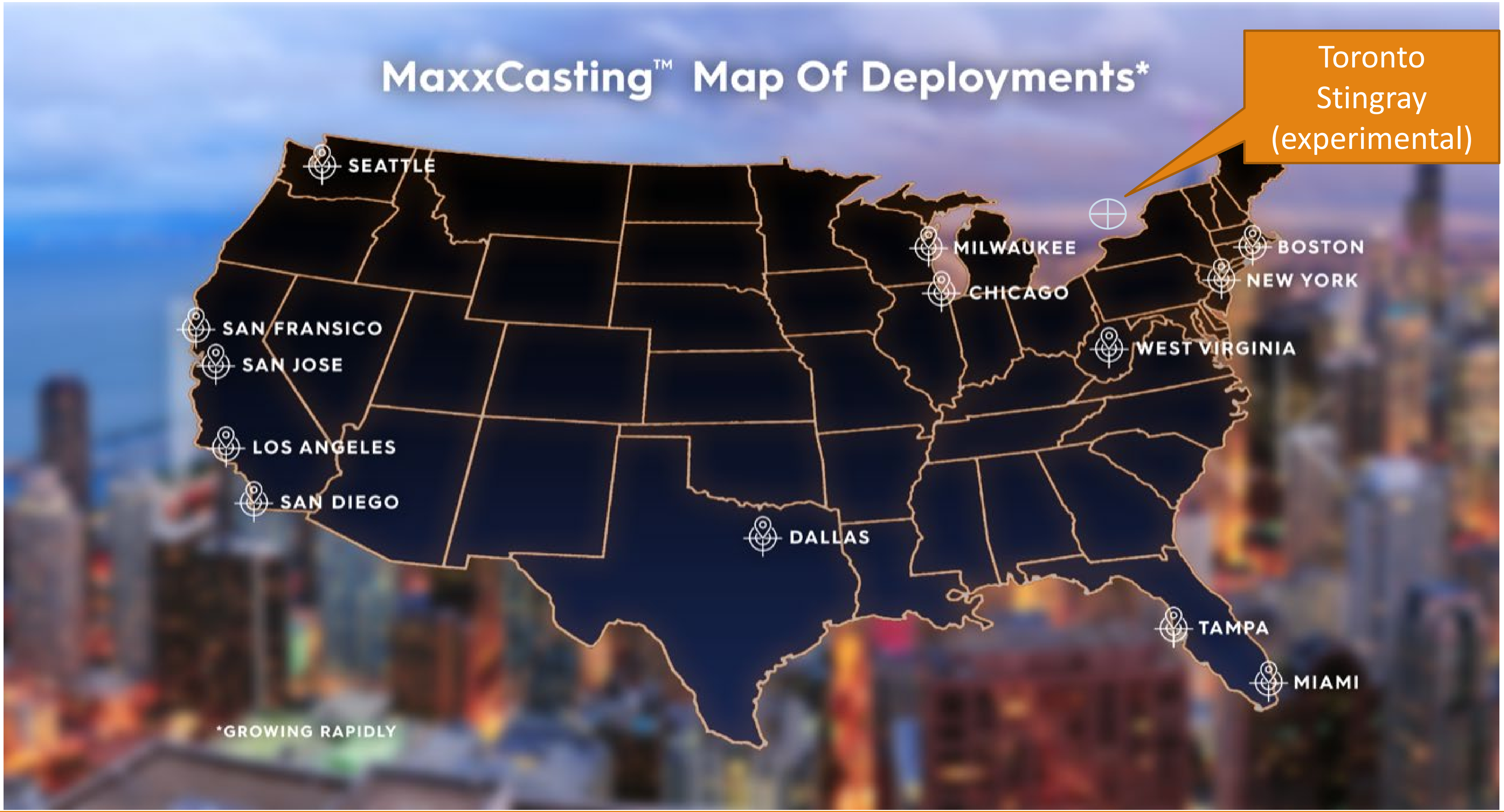
GeoBroadcast Solutions, LLC 2520 St. Rose Parkway Suite 213, Henderson, NV 89074 USA

About Octave Communications

Octave Communications is a Canadian engineering consulting firm which specializes in radio broadcasting, telecommunications and RF analysis measurement software. Our mission is to ensure that our clients are provided with a range of industry leading, innovative and diversified services. Our company's goal is to be your partner 'par excellence' to transform your technological challenges into simple and efficient solutions. Since January 2022, Octave Communications has been selected as the exclusive reseller of GBS MaxxCasting™ in Canada.

Octave Communications, 130 Lallier st, Granby (QC) J2H 0R2 CANADA

MaxxCasting™ Deployment



MaxxCasting is a patented system of FM Single Frequency Network (SFN) deployed to enhance FM coverage

GBS Specializes in the planning, modelling and deployment of the radio broadcast signal to maximize coverage, ratings and revenue in USA

- GBS uses modern cellular 5G, broadcast and SFN software tools with the newest geospatial data-including high resolution building heights, vehicular traffic, and demographics.

Octave Communications specializes in planning, measurements, software design, NIR Radiation Studies and implementation of FM, DTV, AM and other Radiocommunication Systems in Canada

Many FM stations have impaired coverage in the licensed service area

- Terrain, dense urban construction and adjacent channel interference all impact station coverage

Impaired signals cause a loss of audience that can lead to far lower revenue generation as it lowers the opportunity to get ratings because the signal is not decodable by ratings meters (PPMs)

MaxxCasting is a proven system to enhance station coverage and business results

- Delivering improved coverage to tens of millions of new listeners
- Increased ratings and revenue in over a dozen markets for multiple stations

MaxxCasting enables savvy broadcasters to overcome signal limitations, expand the populations served, improve ratings and increase revenues

FM “on-channel” booster: A Review of the ISED Rules

The Broadcast Procedures and Rules – Part 3, defines the application procedures for FM undertakings.

- Section 8: application for FM Rebroadcasting Stations Within the 0.5 mV/m Contour of an FM Originating Station.
- 8.1 Conditions of assignment: Full-time rebroadcasting stations may be assigned in areas within the protected contour of the originating station where the signal of the originating station is deficient (i.e. field strengths less than 0.5 mV/m due to terrain factors, severe multipath distortion, etc.). In general, full-time rebroadcasting stations may be assigned as class A1, LPFM or VLPFM stations or they may be assigned as “on-channel” boosters.
- 8.2 Application Requirements: An application for a broadcasting certificate for a full-time rebroadcasting station shall be made in accordance with the requirements of sections 2, 3, 4 and 5 [of BPR-3], as appropriate.
- 8.3 Special Cases: It is recognized that, due to the nature of terrain and signal propagation, there may be instances where the options given previously may not be adequate. Therefore, the Department may, at its discretion, authorize other classes for use as rebroadcasting undertakings should the applicant provide sufficient justification. Such exceptions will only be permitted if the applicant can demonstrate that the proposed channel, due to impairments such as short-spacings, is unusable for any other purpose and that an assignment per Section 8.1 is inadequate.
- Similarly, in exceptional cases, the Department may, at its discretion, authorize a rebroadcasting assignment within the 3 mV/m contour of the originating station given sufficient justification.

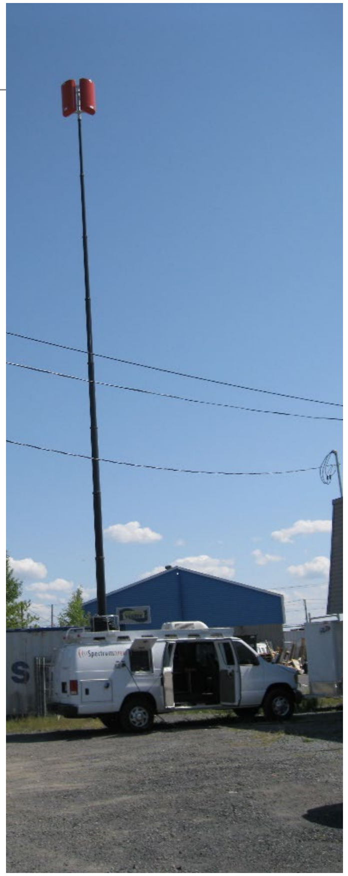
FM “on-channel” booster: A Review of the CRTC Rules

The existing CRTC rules require that the addition of a new rebroadcasting station must be completed according to the Form 303 application: **Form 303 – Technical amendment to a broadcasting license for an analog radio (Including a new transmitter)**

The CRTC treats the 3.0 mV/m as the primary market of <u>commercial station</u>, which defines the zone where that station can seek advertisement. Changing the 3.0 mV/m can be seen as a modification of the primary market and may require additional justification.

- The modification of the 3.0 mV/m market from MaxxCasting™ system deployment will only create a limited zone of 3.0 mV/m located directly in front of the re-transmitter. This zone can hardly be defined has a « new primary market » area.
- The first application for MaxxCasting™ in Canada is presently in the process to be evaluated by the CRTC (12 months pending).

In all cases, the CRTC will require a technical justification for the coverage deficiencies in the 0.5 mV/m secondary market.



Measuring 3 mV/m contour at 9.1m

CRTC Consideration Analysis (1)

The CRTC defines a station's market (from CRTC 2022-332) as :

- [17] For FM stations, the market is defined as the 3 mV/m contour or the central area as defined by Numeris, whichever is smaller.
- [25] In contrast, the use of the definitions based on the 3 mV/m or the 15 mV/m contours can be consistently applied by the Commission as they are based on fixed technical parameters, thus enabling the use of common boundaries and standard data used by the industry and regulatory bodies, in addition to offering greater predictability to licensees.

Unfortunately, the 3 mV/m contour is based on a 9.1m antenna measurement using FCC curves developed in 1950, « modified » in 1966 (Report FCC R-6602) and never been revised since.

Moreover, the Broadcasting Act specifies at section 3(1)d(iv): the Canadian broadcasting system should promote innovation and be readily adaptable to scientific and technological change.

CRTC Consideration Analysis (2)

Based on ITU-R BS.412-9 (1998), the required signal level for an adequate reception is: 48 dBuV/m (0.250 mV/m) for stereo reception without interference

From the « CRC Compatibility Study – Analog and HD Radio (2019) »:

- 14 different FM receivers have been evaluated (table top, car, HIFI, portable, etc)
- When evaluated for a stereo reception (of 10 dB separation)
  - Worst receiver: -69 dBm (48.2 dBuV/m or 0.257 mV/m)
  - Best receiver: -94.6 dBm (21.6 dBuV/m or 0.012 mV/m)
  - Average receiver: -76.6 dBm (40.6 dBuV/m or 0.107 mV/m)
- Additionally, the CRC tests have demonstrated that the actual receiver pool can sustain a much higher D/U levels for 1st and 2nd adjacent reception.

Based on the above, it is clear that the FM reception has evolved greatly since 1966 and the actual market definition is entirely obsolete from a technical point of view. It could be kept as an indicator for ownership and for other commercial / political consideration but the « service contour » of a FM station should, at least, be considered at 0.5 mV/m, which is compatible with ISED's protected contour.

Therefore: usage of SFN on-channel booster should be acceptable allow interfered stations to entirely reach their protected contour of 0.5 mV/m.

Modern Booster Design Refined over years and improved

CARRIER & Pilot- GPS lock via GatesAir's Synchrocast® or Nautel's Digidia SpanFM 10MHz reference

PILOT PHASE- Matched in exciter based upon delay

MODULATION- Must match within 0.25dB

- Now available - digital composite (works best)
- Also possible with regular AES digital if all exciters/stereo gens are matched identically

TIMING- real-time synchronization must be reliable & stable to ≤3µS

ANTENNA- Chosen to reduce delay spread to minimize interference

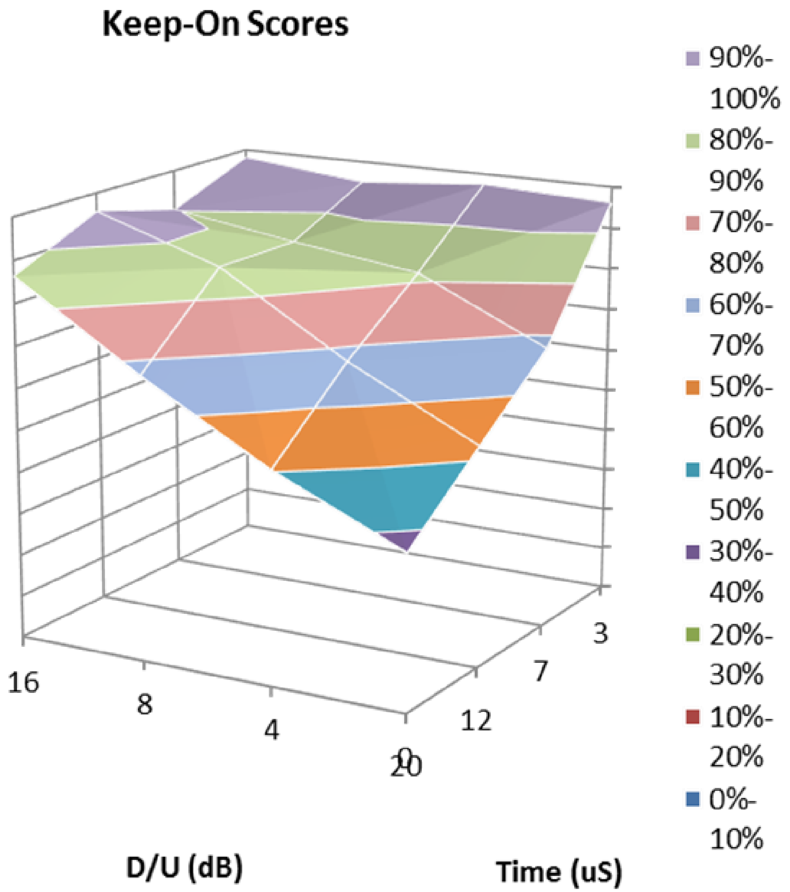
HD SFN- Unique issues implementing boosters with HD primary station. HD system delay must be stable, deterministic

Goal is to minimize self-induced interference. How much is "too much" interference? Until recently, no objective measure.

Determining 90% “Keep-ON” Score

NPR Labs (National Public Radio) Study

- Goal:
  - Create Standardized System Design Criteria for booster systems
- RF Lab Simulations of Main Transmitter booster Configurations
- 19,000 Audio samples evaluated by 80+ listeners - one of the largest studies ever for analog FM radio- Towson University by Dr. Ellyn Sheffield
- Standards for acceptable interference thresholds developed for simulcast and Co-Channel transmission

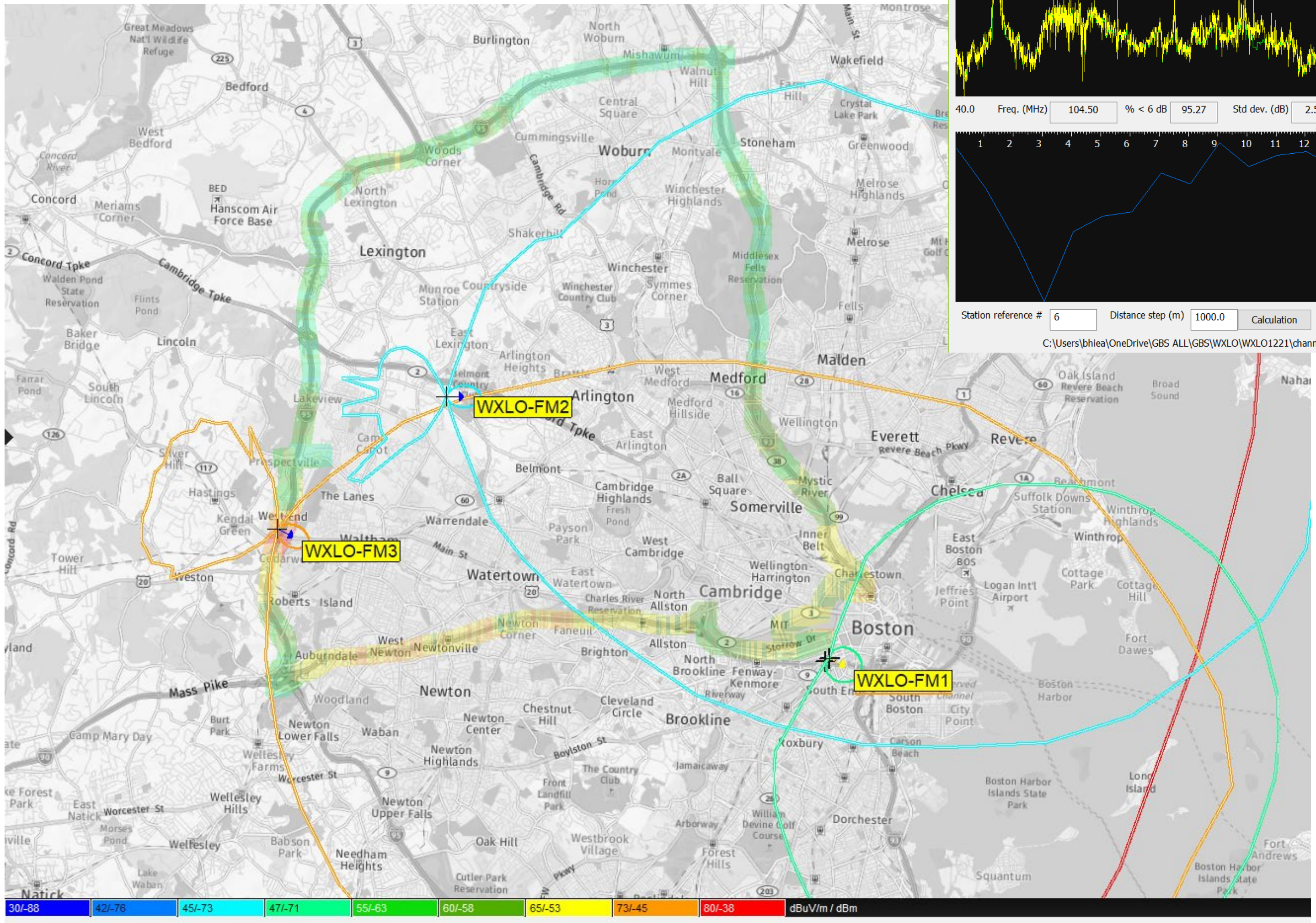


To Establish D/U Ratios Exact Signal Strength Must be Established

How do we know what the RF levels are?

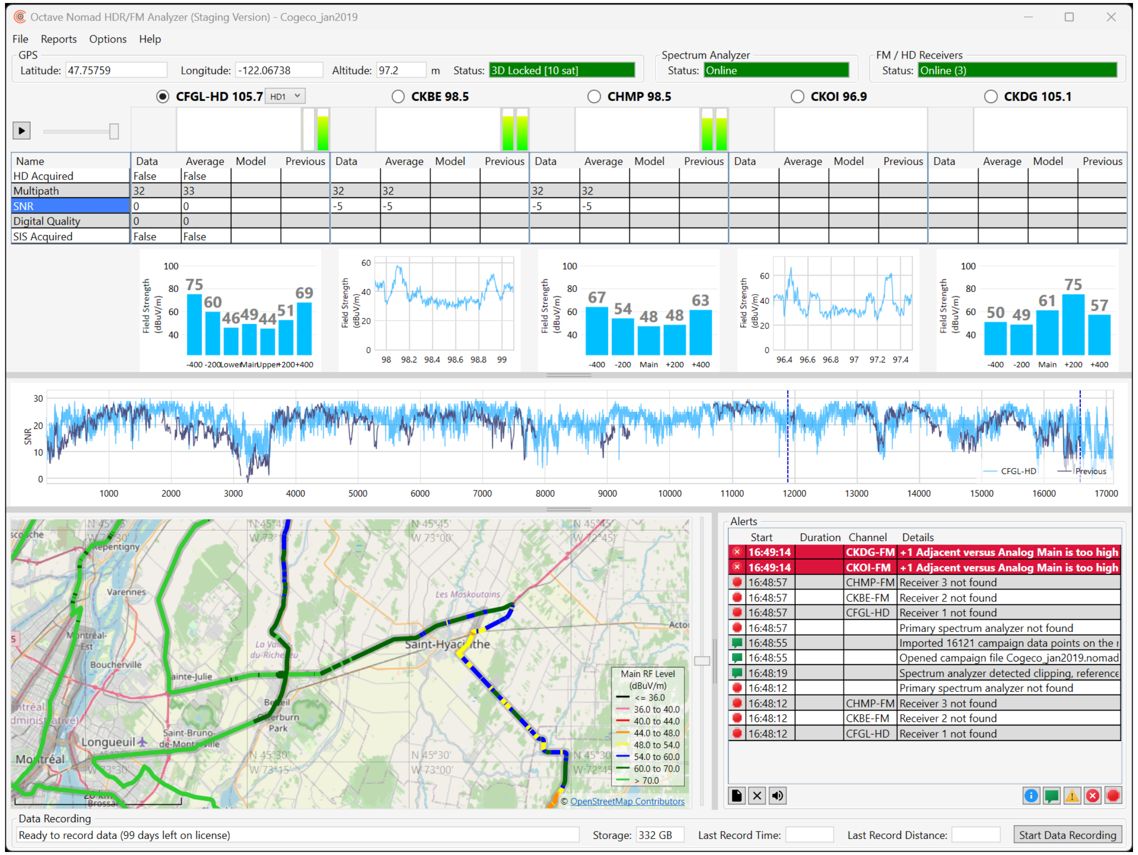
Longley-Rice or Predict is not accurate enough.

- ATDI ICS Telecom Propagation Software
- Model ITU 525/526 with Deygout diffraction



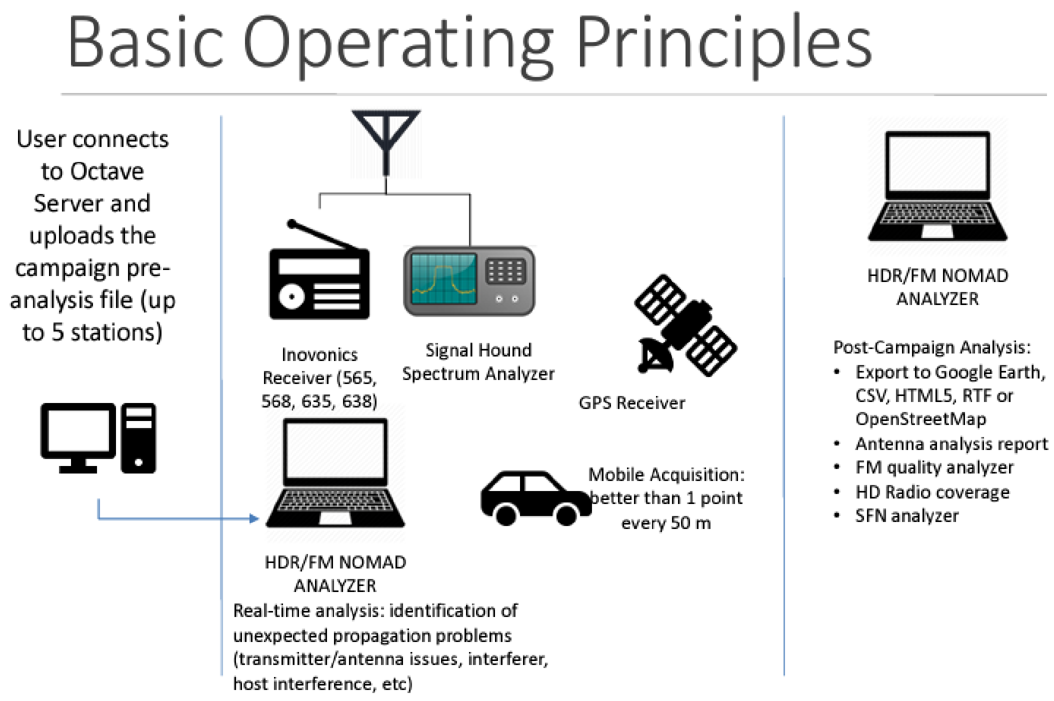
Drive Test Correlation using Octave's Nomad HDR/FM Analyzer with ATDI Model

Performing Measurements: Nomad FM/HDR Analyzer



US Patent: US-20200092020-A1

Nomad FM/HDR Specifications



Hardware used in the system:

- Receiving antenna: DEVA FM-ANT or Firestik K-11
- Spectrum Analyzer: Signal Hound USB-SA44b
- GPS: GlobalSat BU-353S4-5HZ (New 10Hz version available)
- DA: Electroline EDA-2400 or 2800
- Receivers: Inovonics 565, 568, 635 or 638

The System is fully calibrated by Octave to ensure a direct recording of the field strength (in dBuV/m)

- This ensure a very high correlation with the simulation tools (ATDI) octave communications

Why we do measurements ?

Propagation models are limited by their inherent accuracy and by the quality of their database.

- Model training using measurement data

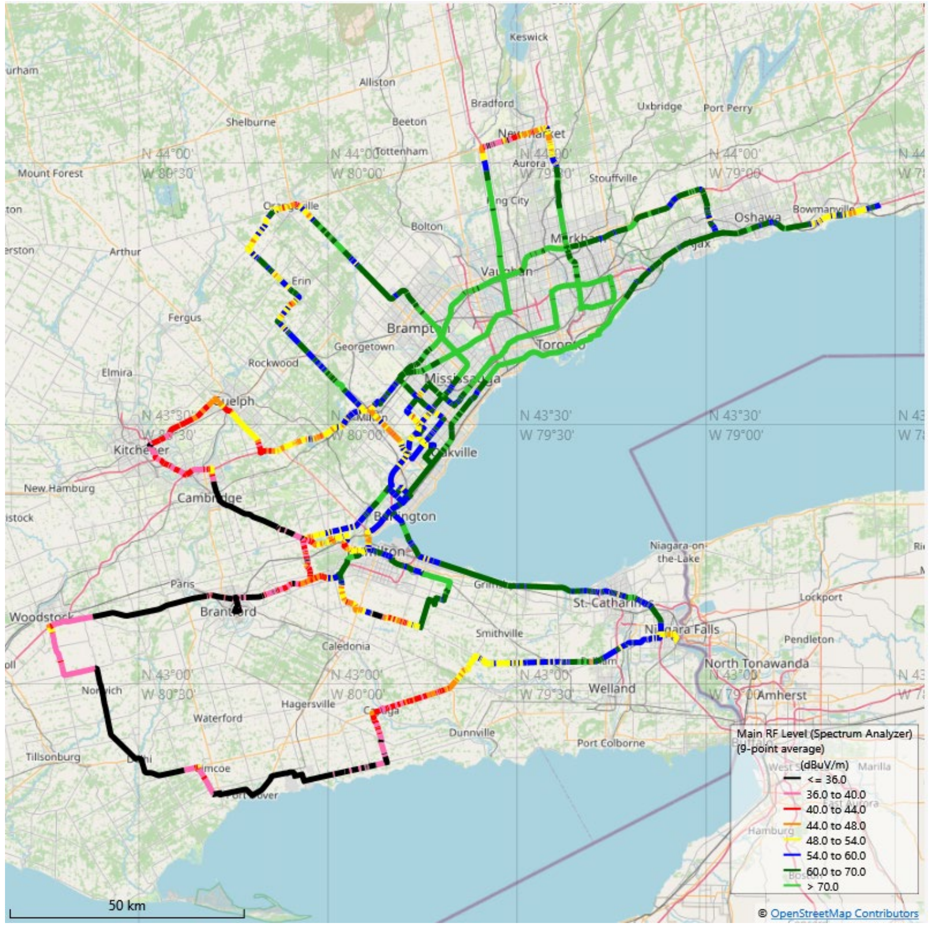
This is the only way to confirm that the transmission site is implemented as per its design.

Making sure that directional antenna patterns are met.

Identifying interfering stations.

Comparison with previous measurements (after a change of parameters)

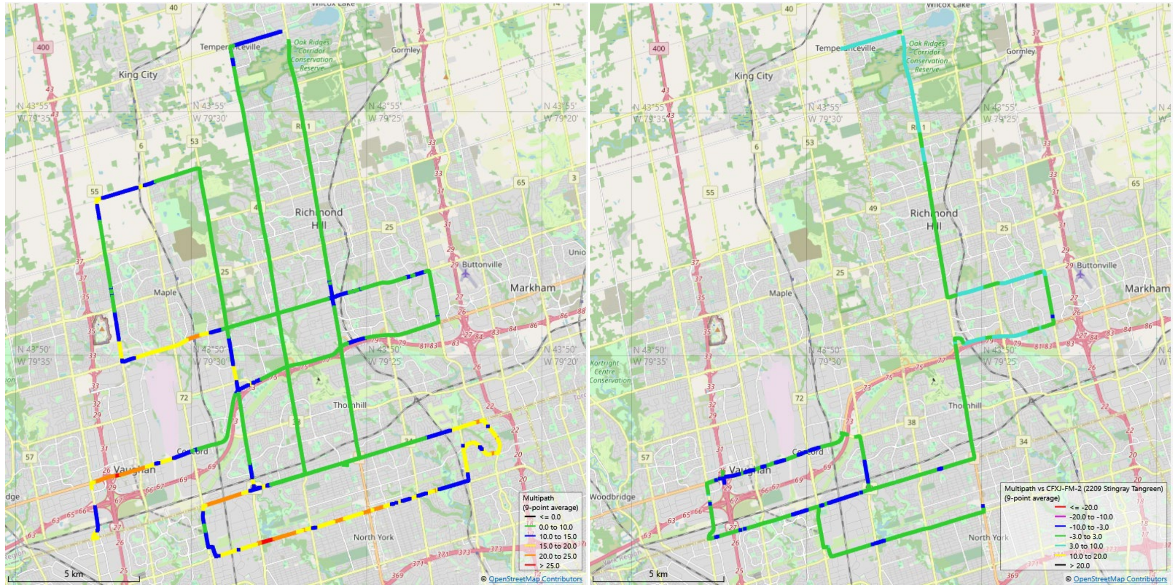
Synchronizing SFN Maxxcasting FM Repeaters

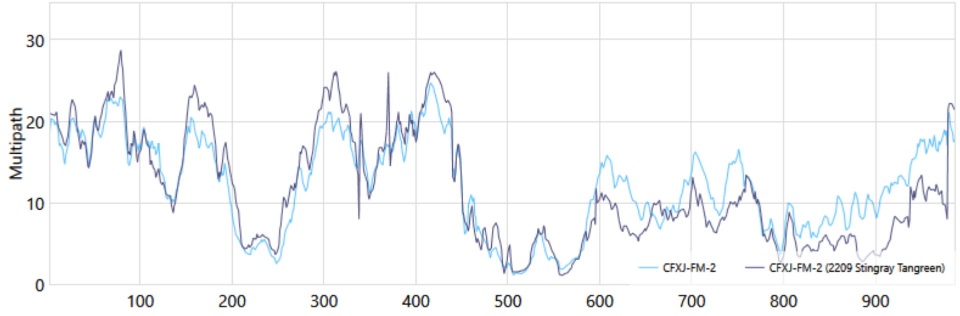


How to synchronize a Maxxcasting booster

FM is a analog signal where the absolute received power does not relate necessarily to a better reception.

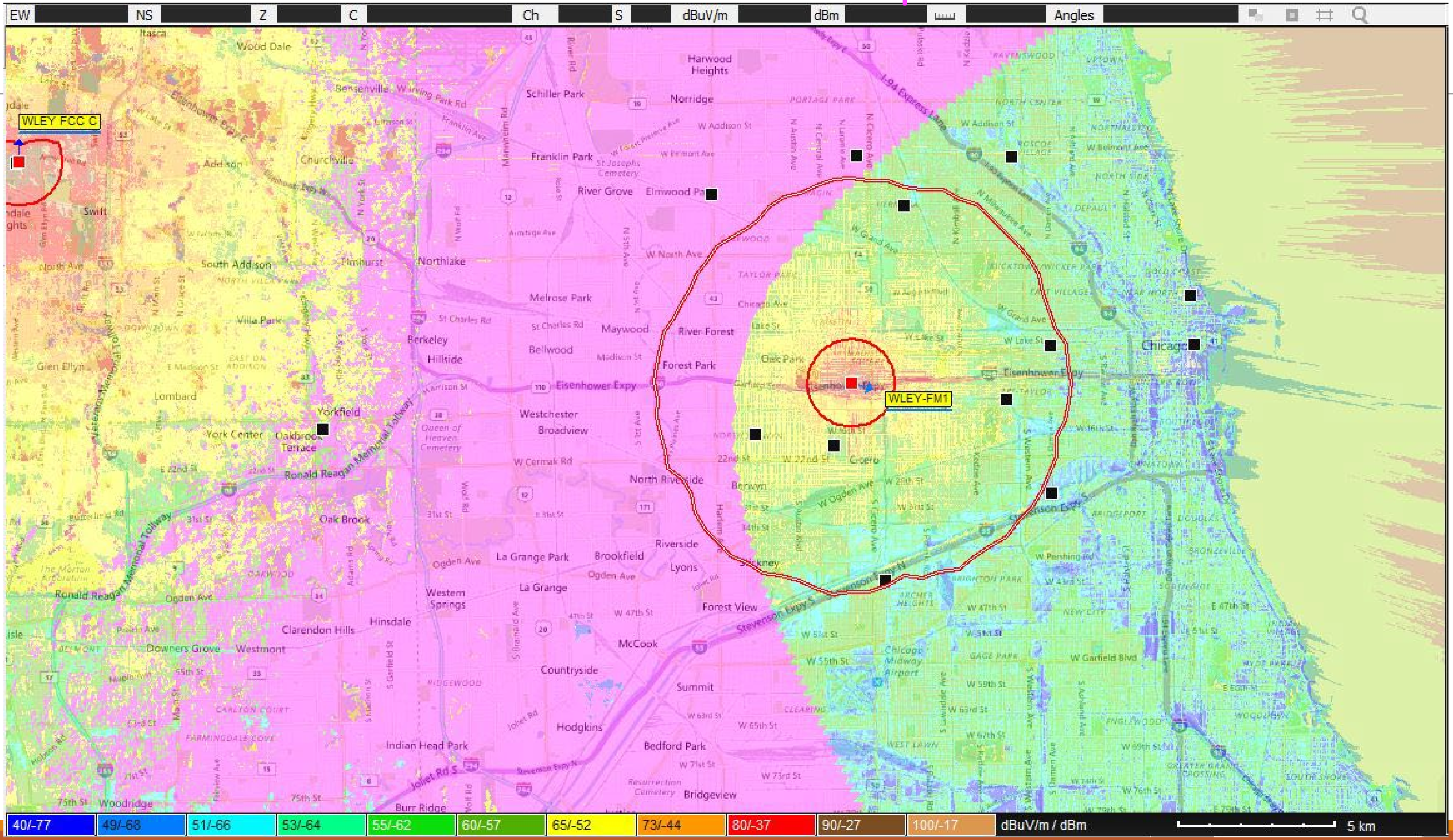
The Inovonics 568 and 638 receivers provide a multipath level evaluation of surrounding echoes that degrades the analog reception (lower the multipath level, less unwanted echoes). Since the booster is an “active” echo, we can use this metric to fine tune its synchronization to compensate for local obstructions, antenna pattern and other surrounding boosters.



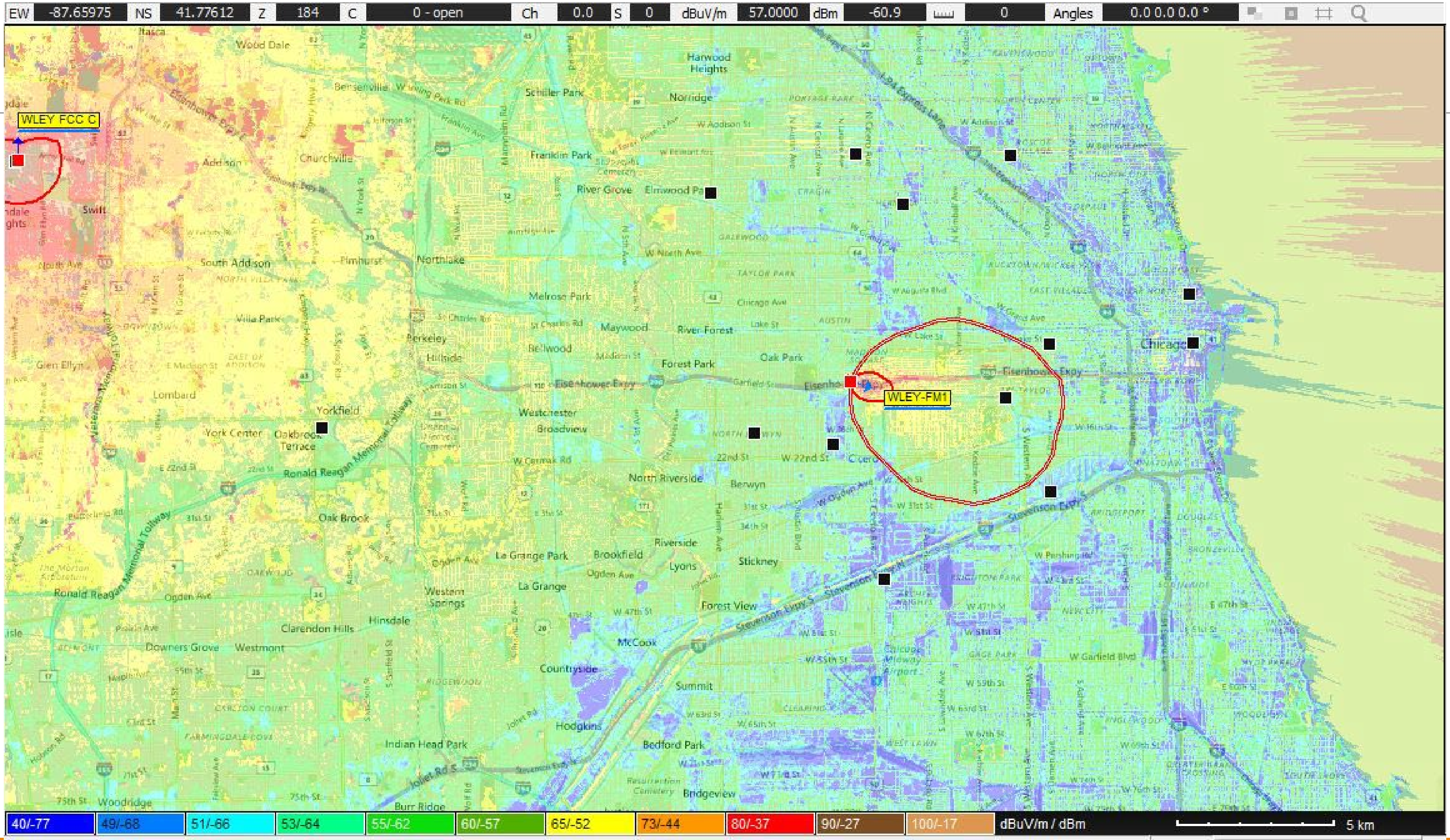


Interference Analysis: Synchronous Omni, 90uSec Delay

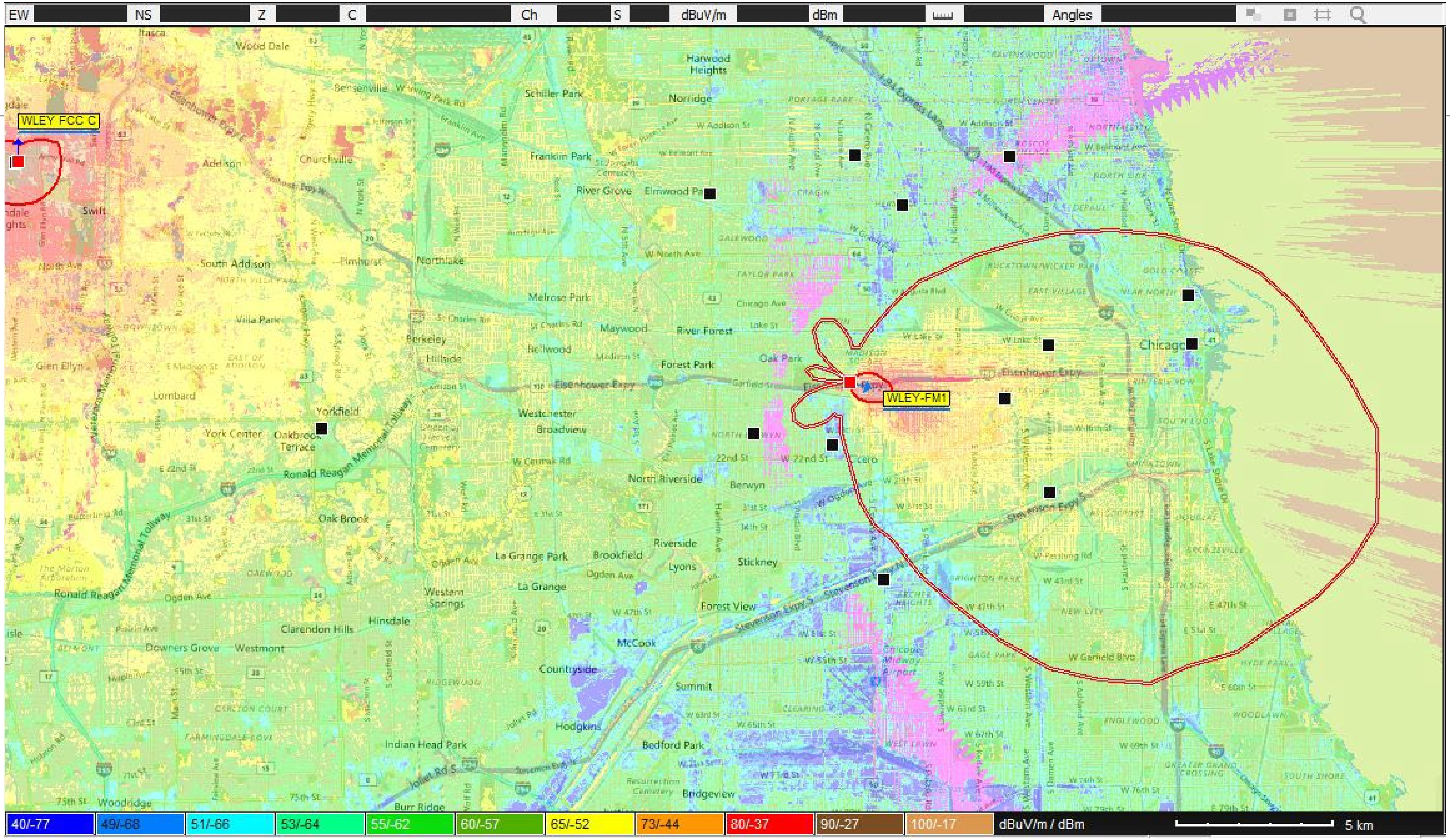
MAGENTA Indicates below 90% "Keep-On"



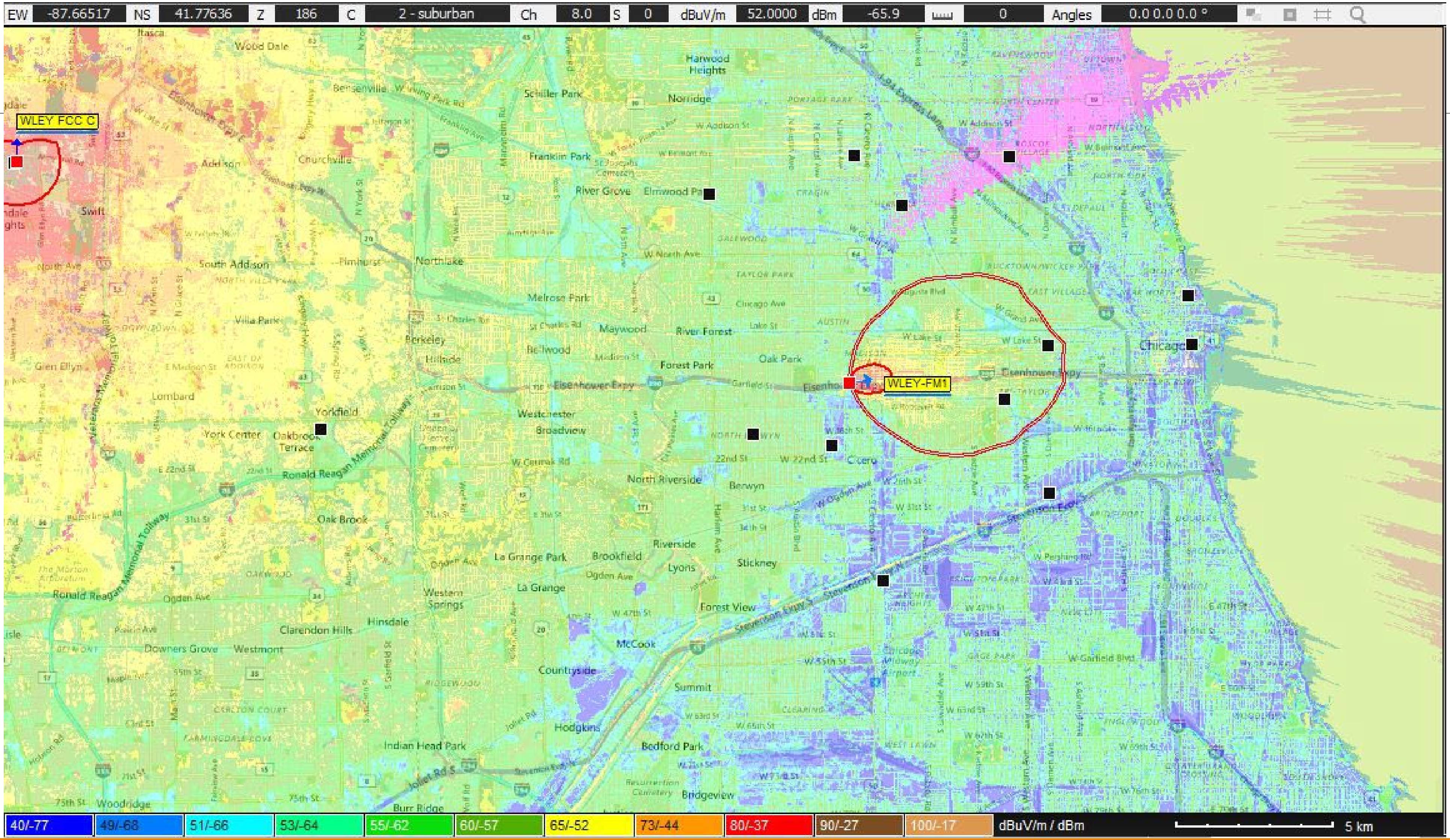
Interference Analysis: Synched Dual Log Pattern at 105°, 99w, 90uSec Delay



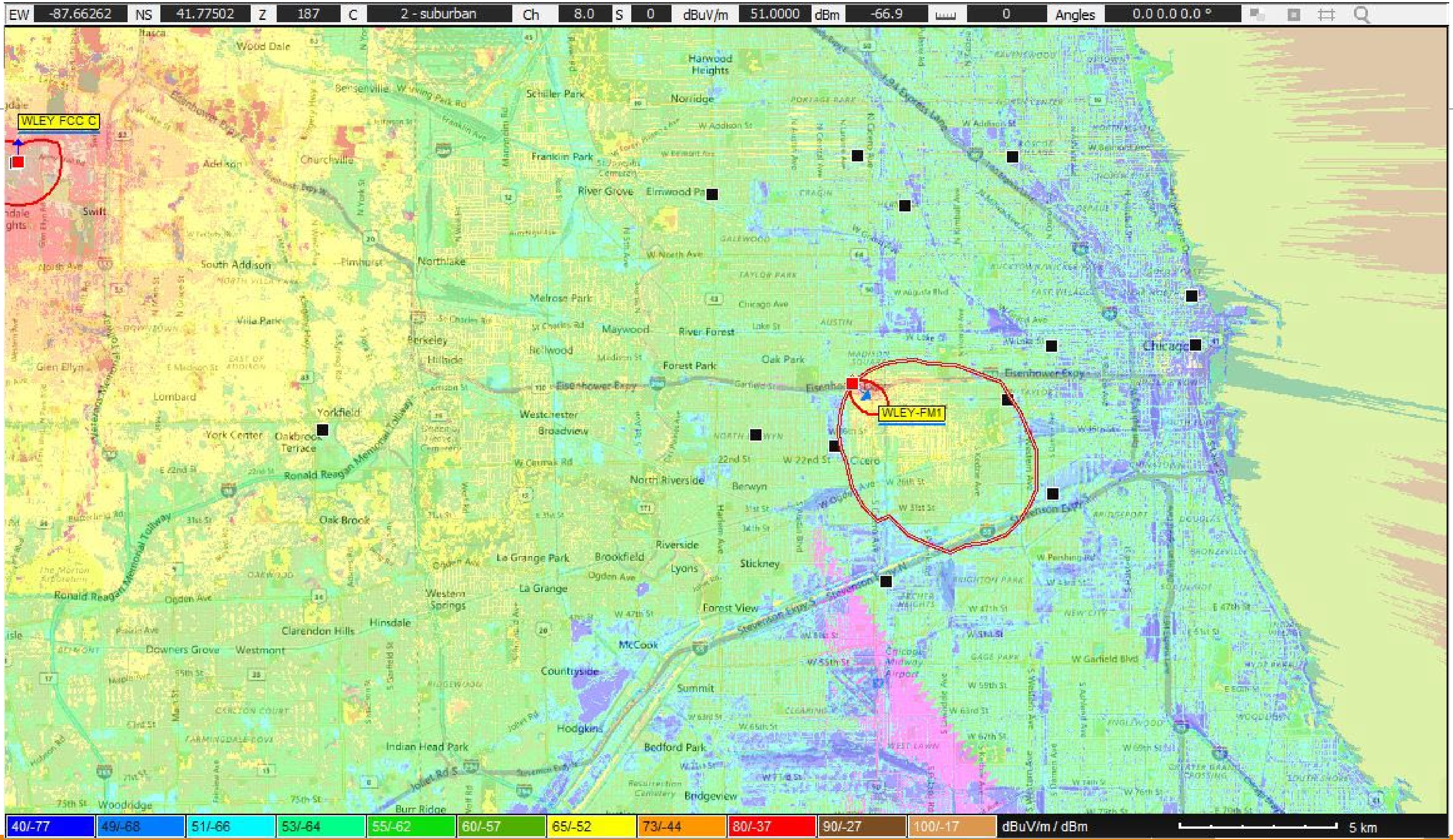
Interference Analysis: D/U Ratio, 15dB Boost with 90uSec



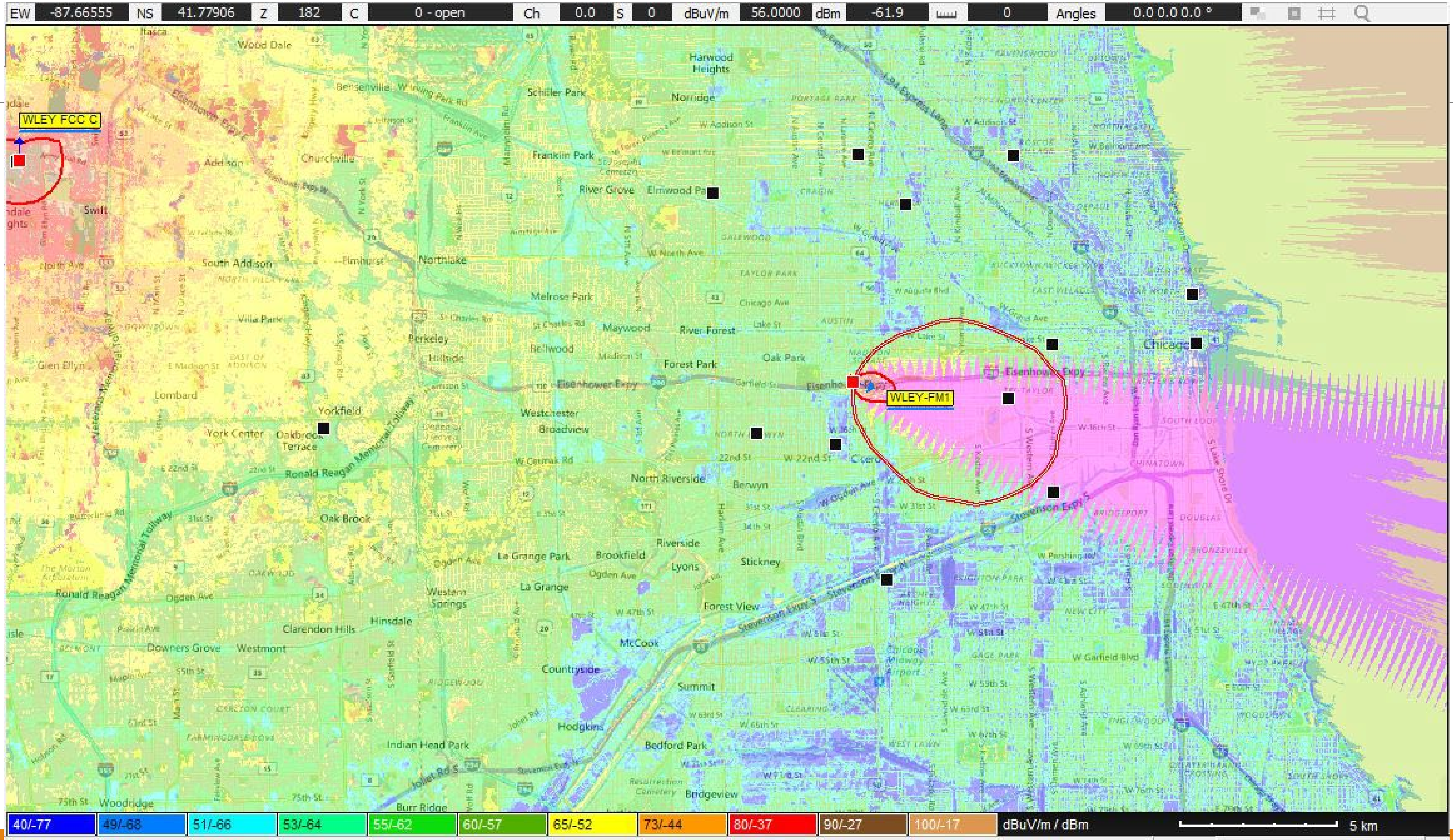
Interference Analysis: Antenna Orientation at 80°



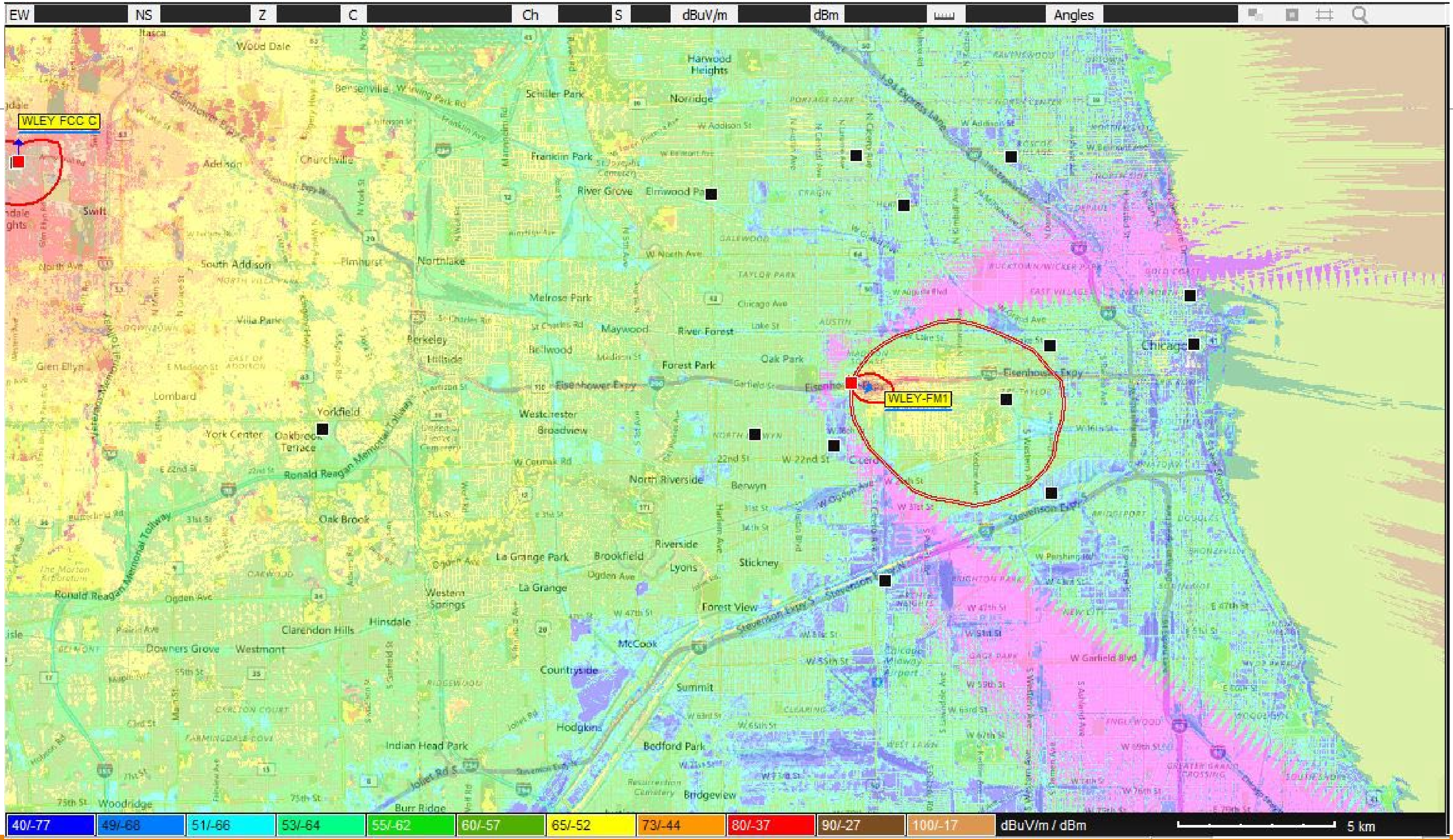
Interference Analysis: Antenna Orientation at 130°



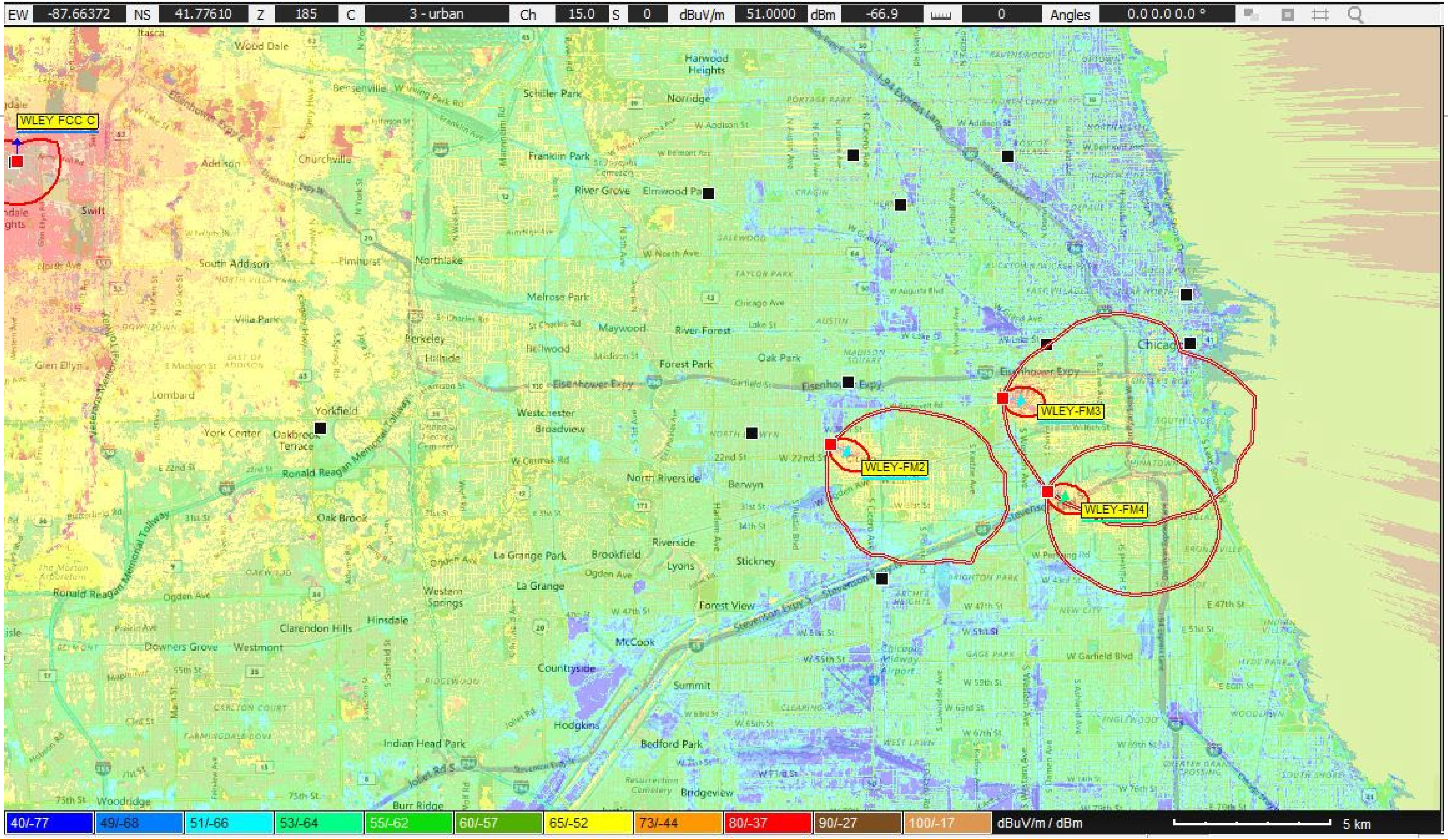
Interference Analysis: Time of Arrival at 78uSec



Interference Analysis: Time of Arrival at 100uSec



Maxxcasting Interference Analysis: Multiple nodes



Maxxcasting Technical Equipment Set Up

Antennas are critical: Dual Log-Periodic antennas, 30deg "roll", for slant polarization.

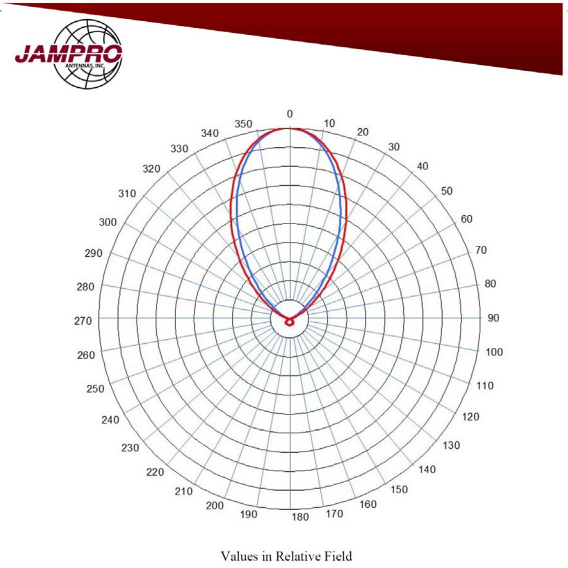
A high capacity IP microwave or data circuit (preferably private), Speed of about 3-5mbps minimum for digital composite, low latency. Add for E2X if HD is used

GatesAir IP Link Systems with Synchrocast. We've standardized on MPXp digital composite for the analog

Other solutions are possible: Nautel-Digidia SpanFM

Exciters and exciter software versions must match or timing/ modulation synch may suffer. Approved currently on GatesAir and Nautel exciters

HD- Now operational HD Main w/ Analog Boosters OR HD Main and HD Boosters. Operating at KWFN San Diego; WKVB Boston; KOIT, KMVQ, KBLX San Francisco and CFXJ-FM Toronto.



Jampro JAVA-1-1(2) optimized antenna pattern

Single set of antennas

Rack from typical node

Key Steps to SFN Booster Design

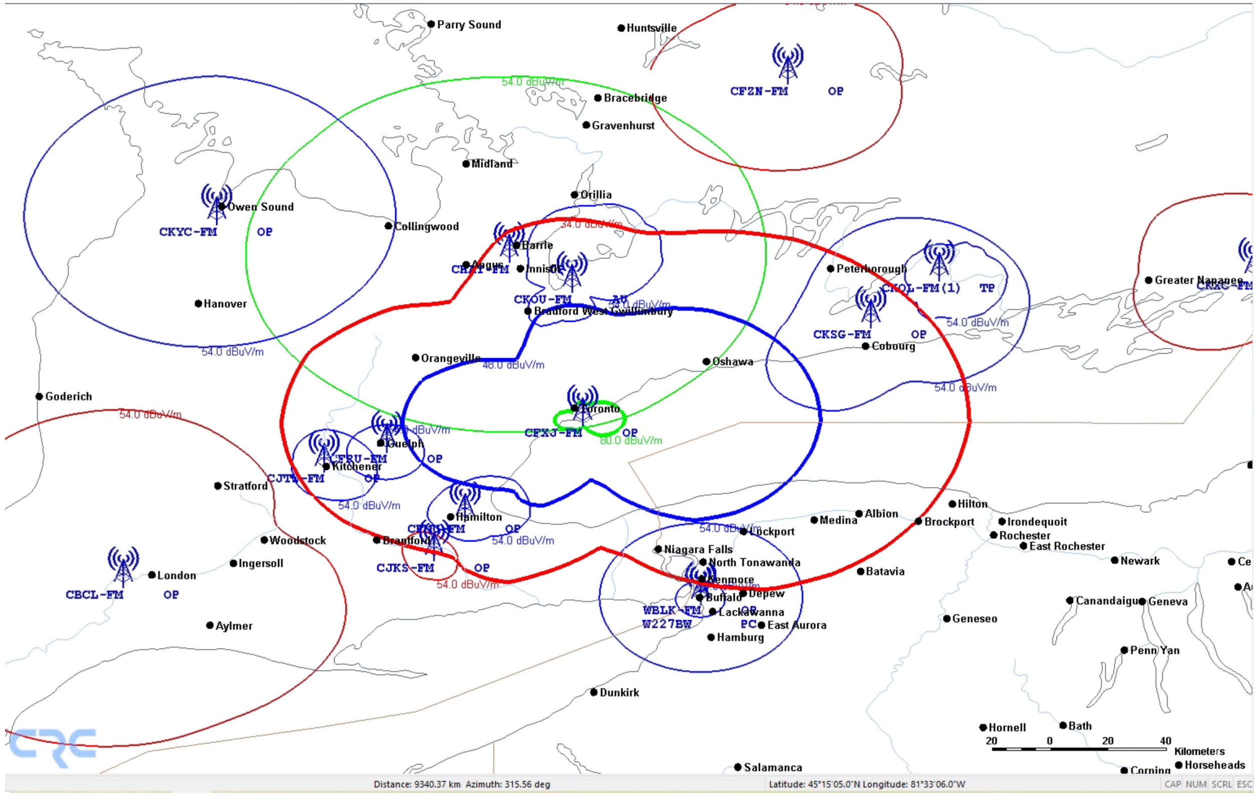
1. Problem investigation
   - Identify the area of problematic reception and their causes (interference, urban obstacles, terrain, etc)
2. Complete a detailed measurement campaign of those areas to characterize the signal reception
   - The campaign data is used to confirm the problematic areas and train the model. This is necessary in order to best design the necessary repeaters
3. Potential site findings
   - Identify a list of sites that can be used for repeaters in the problematic area
4. Simulate the potential coverage improvements
   - Using advanced simulation tools (ATDI) with improved terrain, clutter and building database. Comparison with measurements is also essential
5. Select adequate hardware
   - It is really important for your hardware to be compatible with your network. Antenna patterns are also crucial as they need to have a very stringent front-to-back ratio and need to have very limited sidelobes.
6. After installation, proceed with detailed synchronization measurements
   - The synchronization can always differ a little from the theoretical values (additional delays due to hardware). Remember that we are fighting against the speed of light ! Some in field adjustments can also help in solving pre-echoes situations.

Step 1 – Problem Investigation: CFXJ-FM Stingray Toronto

CFXJ-FM is a class B station (3,706 W ERP at 298.7 m EHAAT) broadcasting from the First Canadian Place in Toronto.

The station parameters are maximized at the existing antenna pattern due to the surrounding existing stations.

Due to fast growing suburbs, limited ERP and incoming interference, the 0.5 mV/m contour does not provide adequate reception.



Brampton: a fast growing suburb

BRAMPTON 1985

BRAMPTON 2022

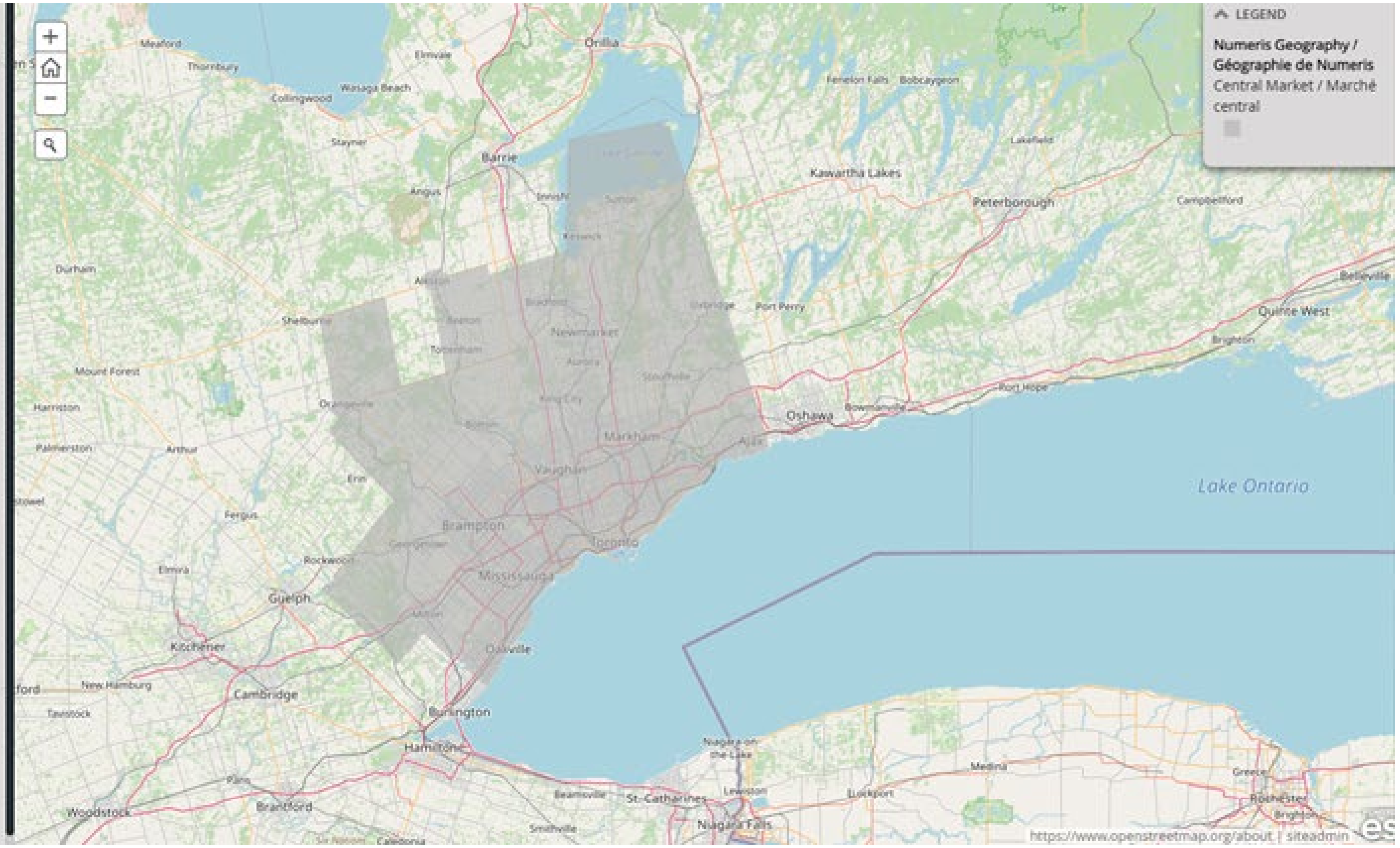
Market Consideration

Toronto Numeris Market

Market Summary
5199 - Toronto CTRL

Population and Households ('21-'22)	
Population (12+)	5,856,320
1-Year Pop Change	-0.10%
Households	2,372,940
1-Year HH Change	0.80%
NHS Statistics (Census '16)	
Unemployment Rate	5.1%
Commute by Car, Truck, Van	38.3%
Annual Avg HH Income	$104,100
Education above HS Diploma	56.9%
Sample Statistics (SP21)	
Target	6,000
Returns	5,995
Over/Under Target	0.00%

Source: Environics Analytics, Statistics Canada.



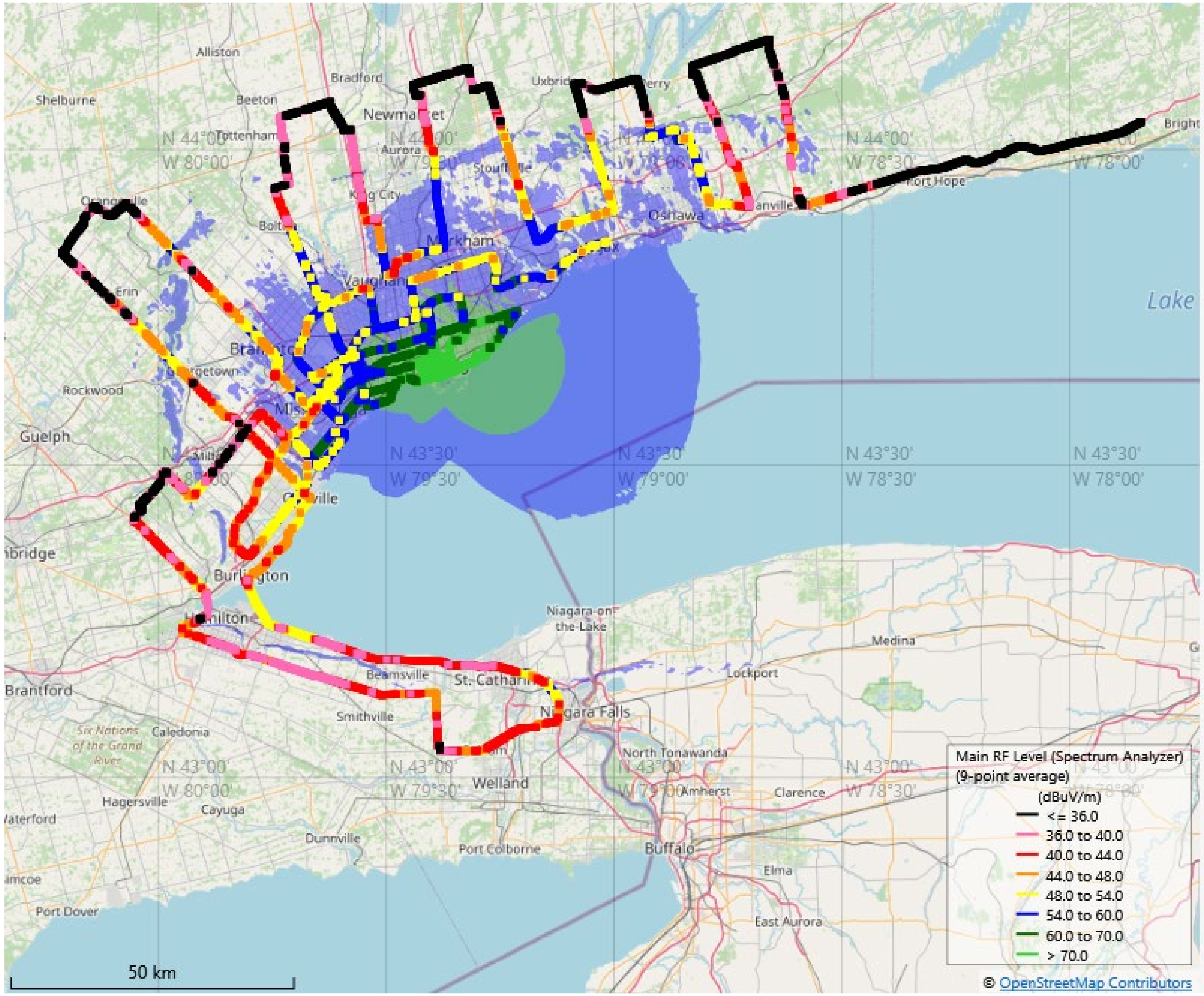
Step 2: Complete Detailed Measurements

In order to confirm the problematic areas, we use the Nomad FM/HDR Analyzer to record the RF levels and key metrics to assess the existing coverage of the station.

The RF levels are used to best tailored the propagation model that will be used to simulate potential repeater locations.

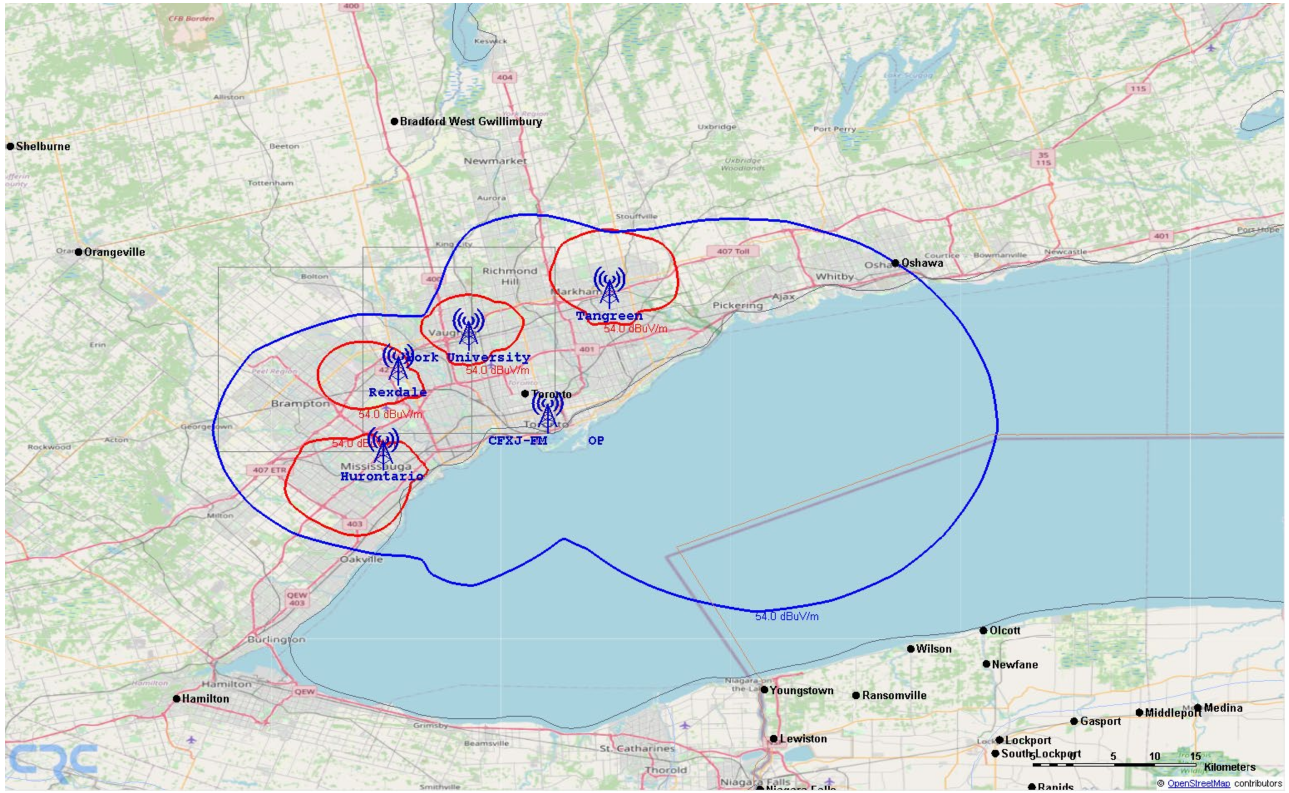
The multipath levels are used to derive the demodulated audio quality.

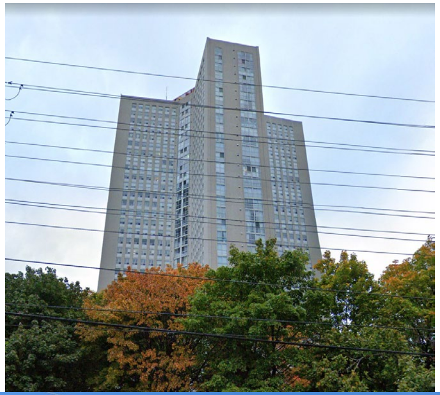
We also assess the HD Radio coverage quality of the station

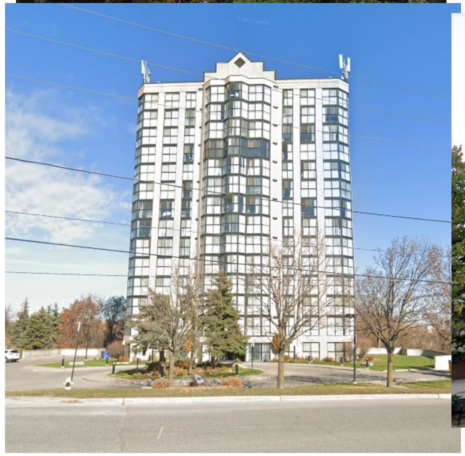


Step 3: Identifying Potential Sites

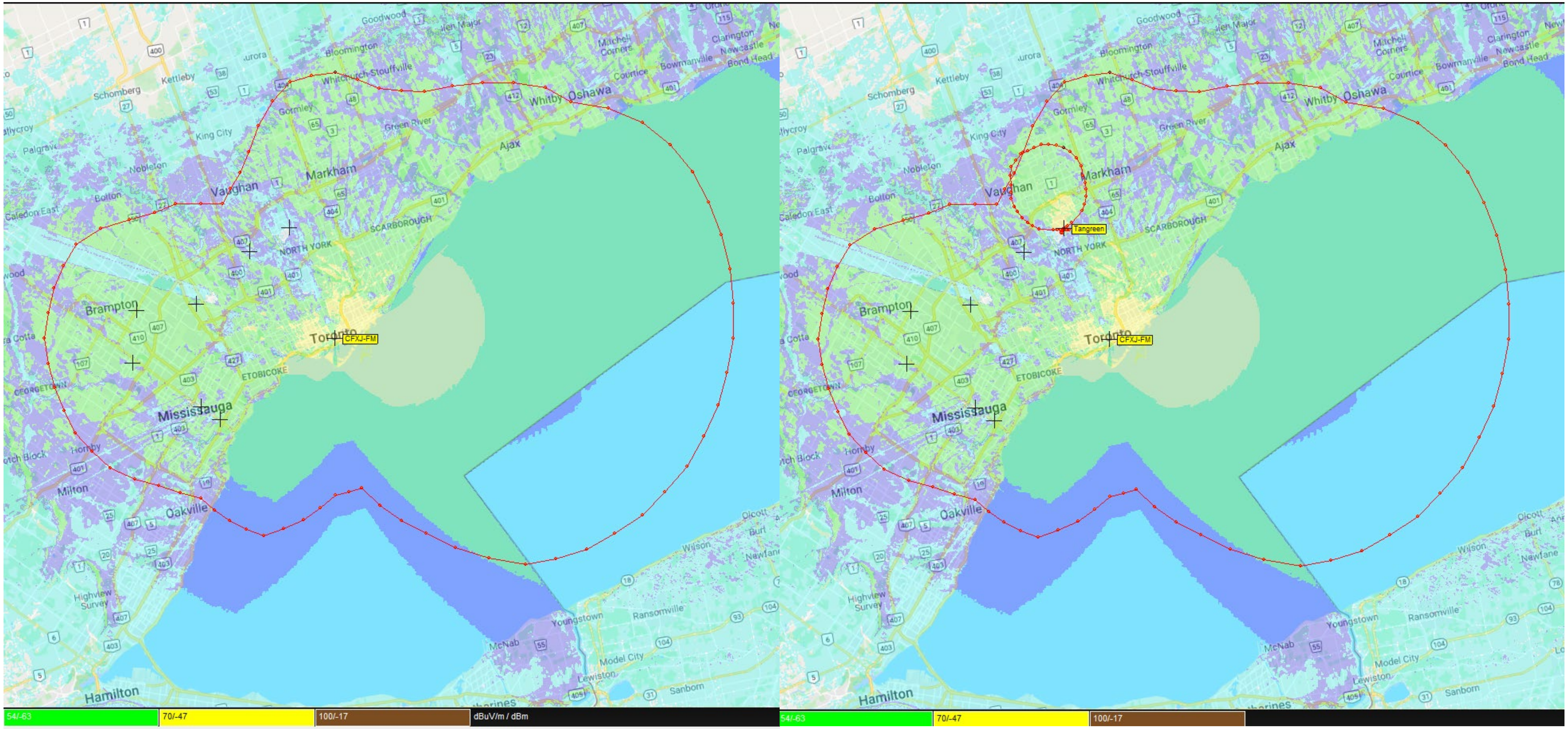
Once we have assessed the problematic areas, with the potential population losses, we proposed a first plan with potential repeaters. We then evaluate which repeaters are providing the greatest improvements (based on population or other coverage objectives). We prioritize the sites and start looking for potential buildings for the implementation.







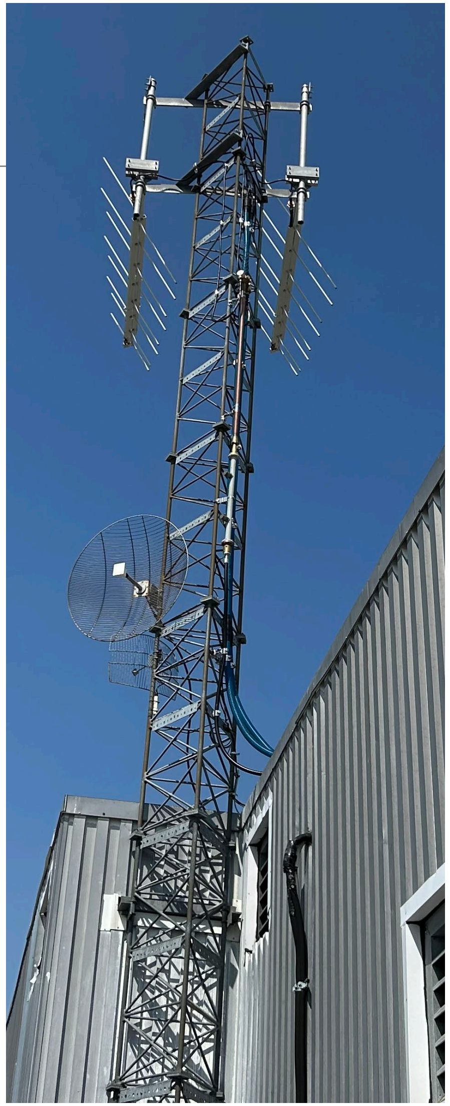
Step 4: Simulate the Coverage Improvements



Step 5: Select the adequate hardware

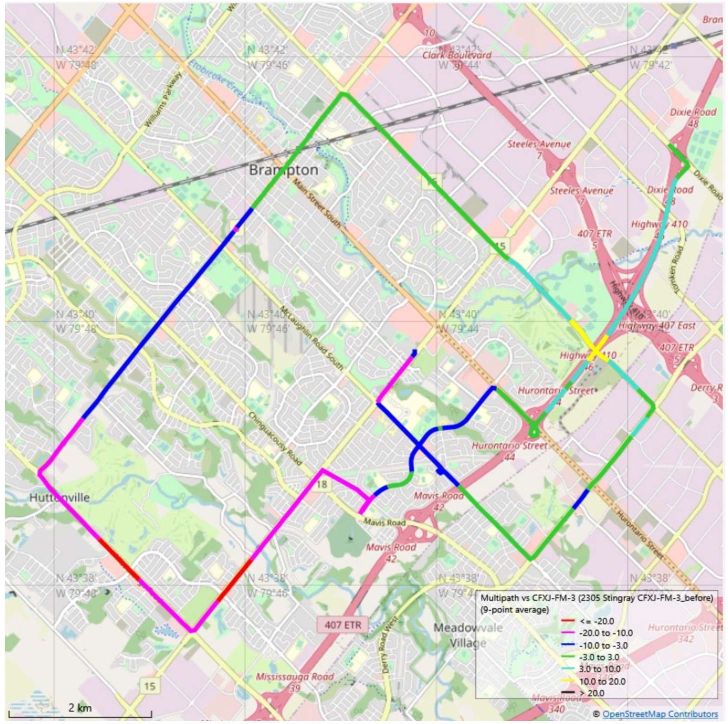
For this project, we have used the following hardware equipment for the constructions of the different sites:

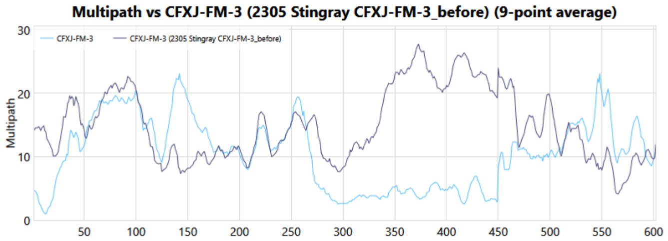
- Transmitter: Nautel VS300 with HD running at -10 dBc
- Synchronization and Distribution Interface: Nautel Digidia SpanFM
  - Note: instead of distributing the modulated MPX signal, SpanFM distribute the audio in MPEG Format. In order to keep the same consistency in the audio levels and delays, we must distribute the digital processed output of the main compressor at the head-end. It is also important to compensate for the modulator delays (if any) at each of the nodes.
  - Other solutions would have been the usage of GatesAir Synchrocast which distributes a digitized version of the MPX.
- Monitoring:
  - Davicom, Inovonics Sofia 568, Inovonics Modulation Monitor 552 (Analog and HD)
- Antenna:
  - Jampro JAVA 1-1(2): this antenna has a special setup design for Maxxcasting application with a smaller back lobe
  - Scala Dual CL-FM: sites were implemented using the antenna but higher sidelobes required to pull the synchronisation in the back, which degraded some of the coverage in the distance main lobe.

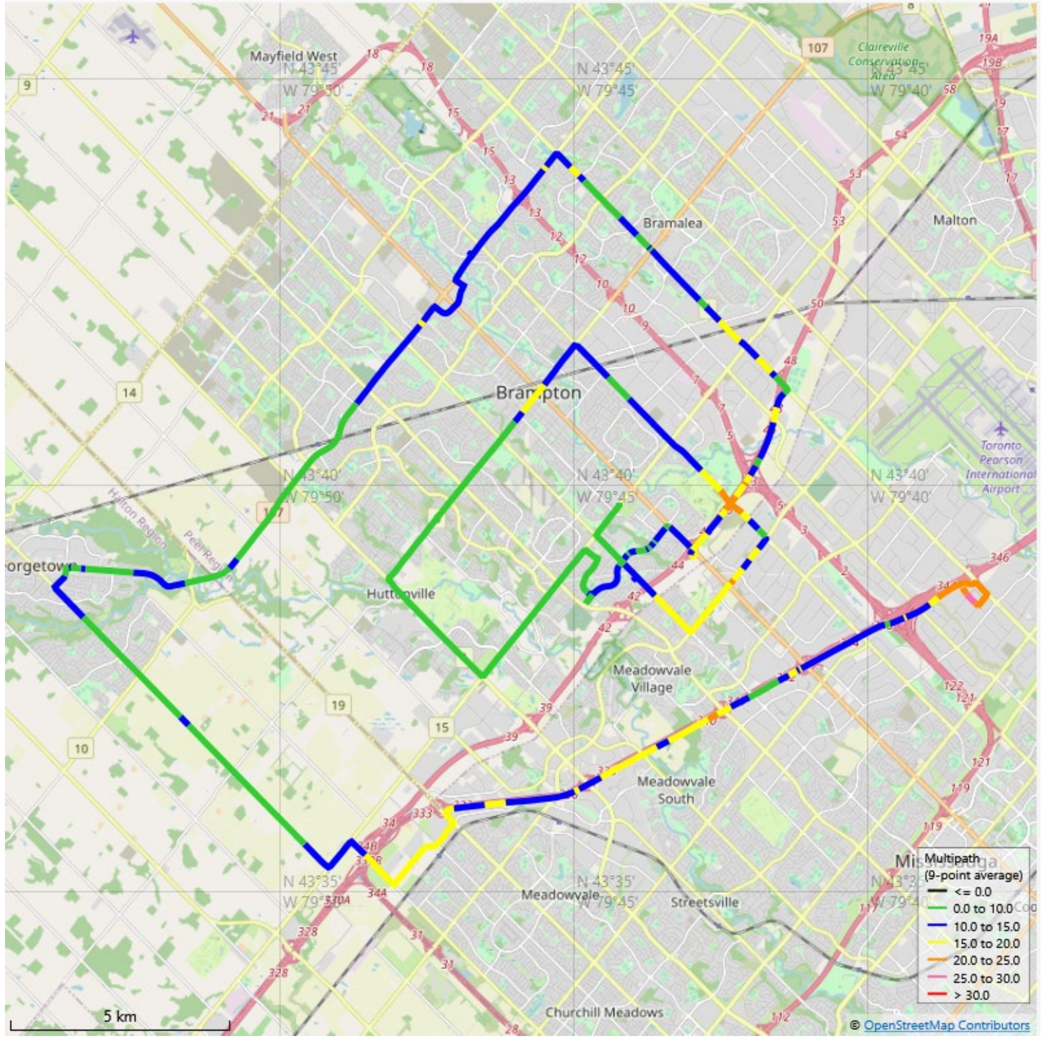


Step 6: Field Synchronization

The simulated parameters are never perfect. We need to compensate for the modulation, IP, or other unforeseen processing delays.

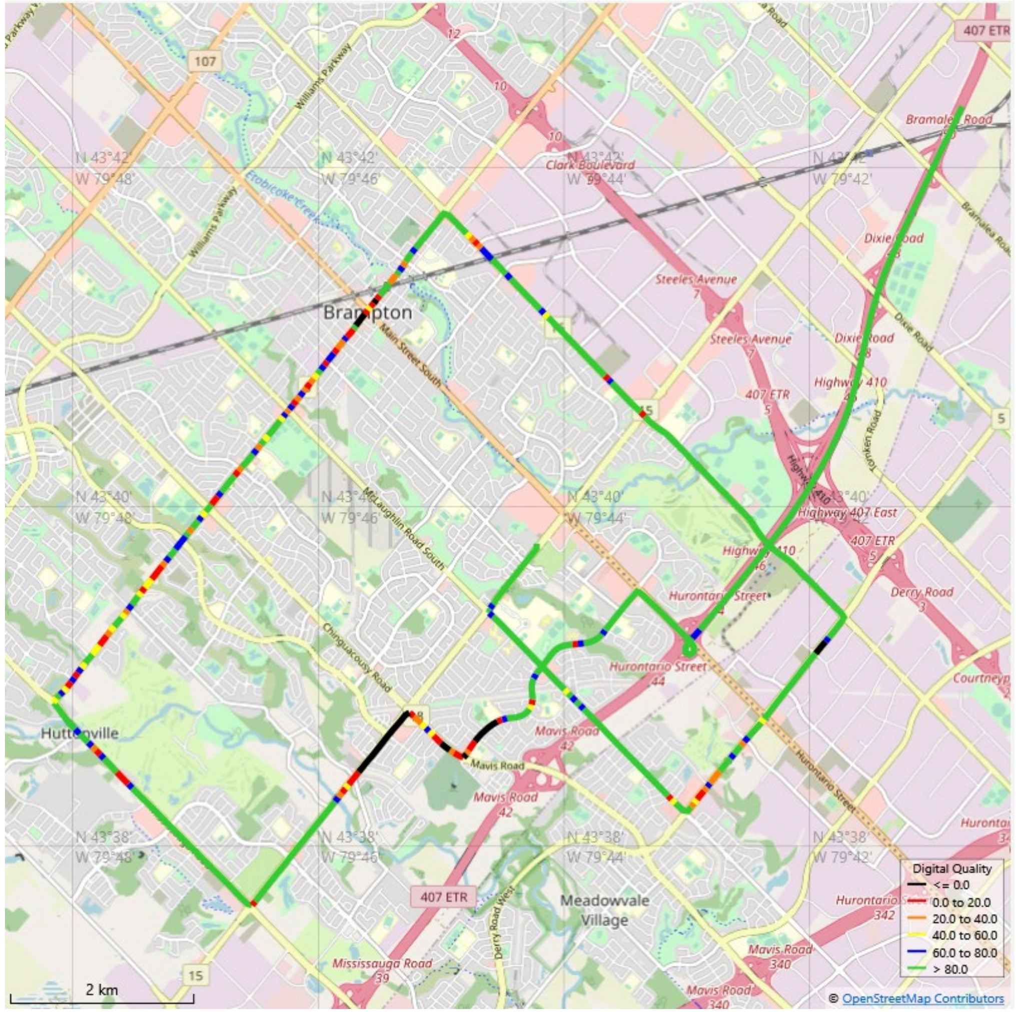


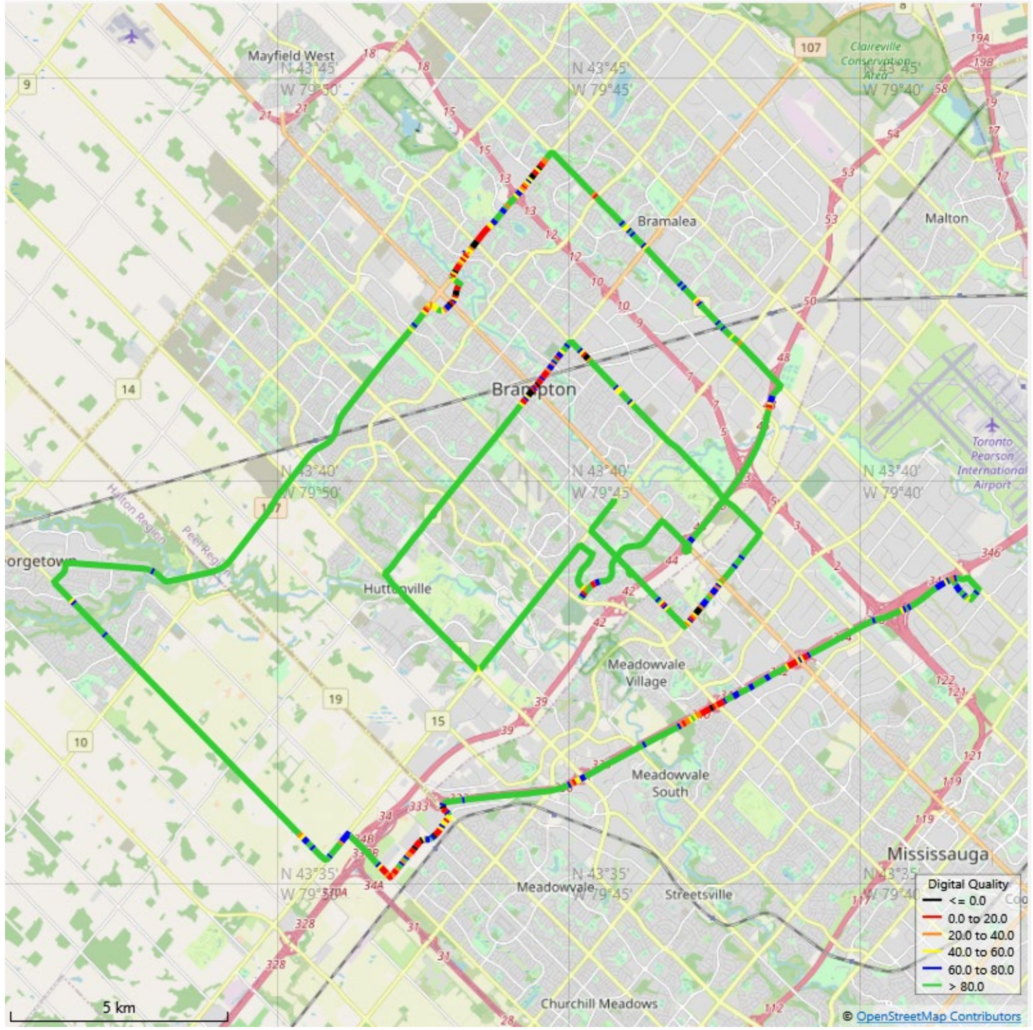




Step 6: Field Synchronization - HD

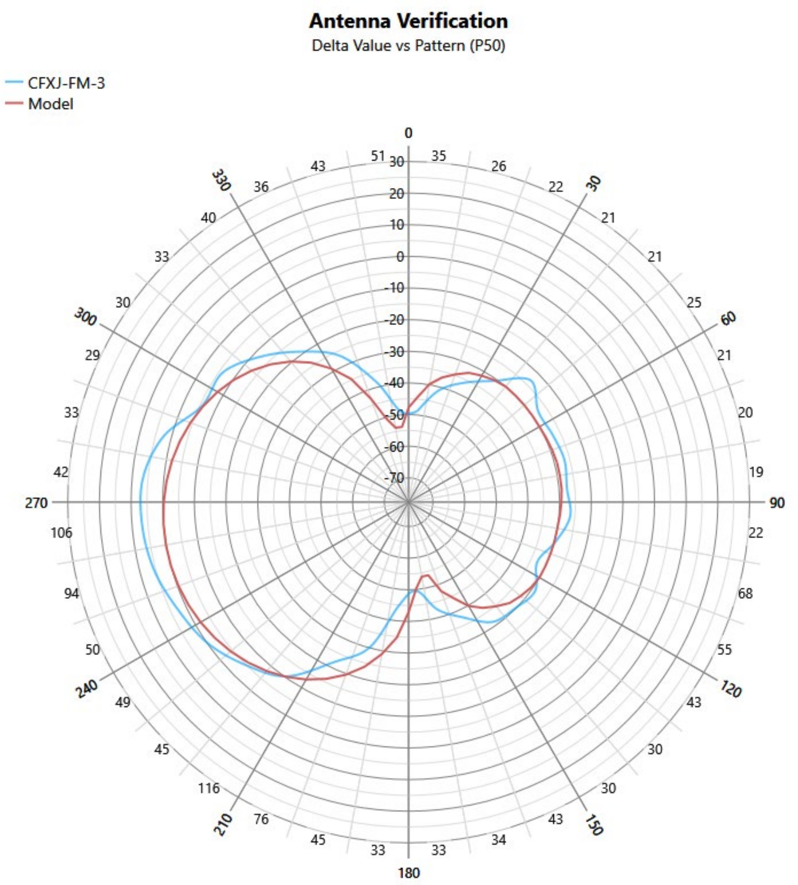
Usually, the HD signal is « easier » to synchronize.

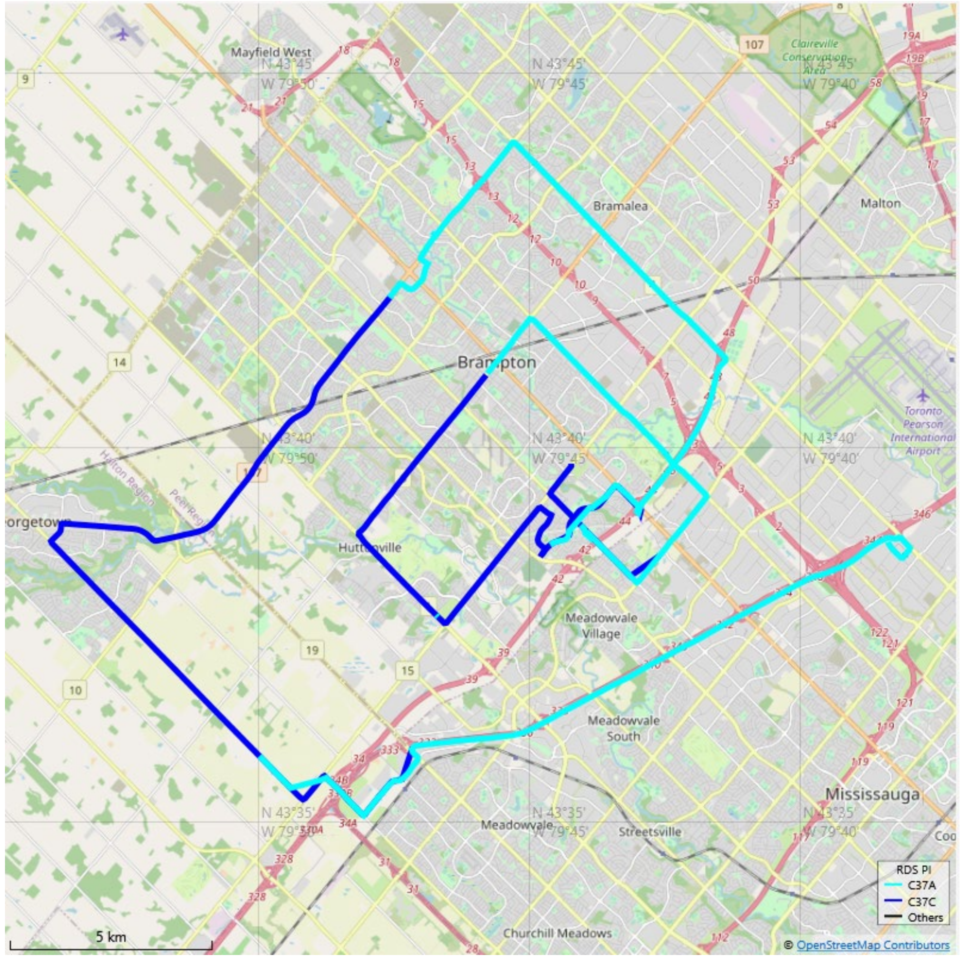




Step 6: Field Synchronization (3)

We can evaluate the resulting booster antenna pattern and the area where the booster was the strongest contributor, by recording the strongest PI code:





Listening is believing !