



# FM Boosters 2.0

## *It's Not Your Father's SFN*

April 8, 2018

NAB Show 2018

Featuring  
GatesAir's



Rich Redmond  
Chief Product Officer

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# FM Boosters 2.0 – It's Not Your Father's SFN

Rich Redmond - GatesAir

Hal Kneller – Geo Broadcast Solutions



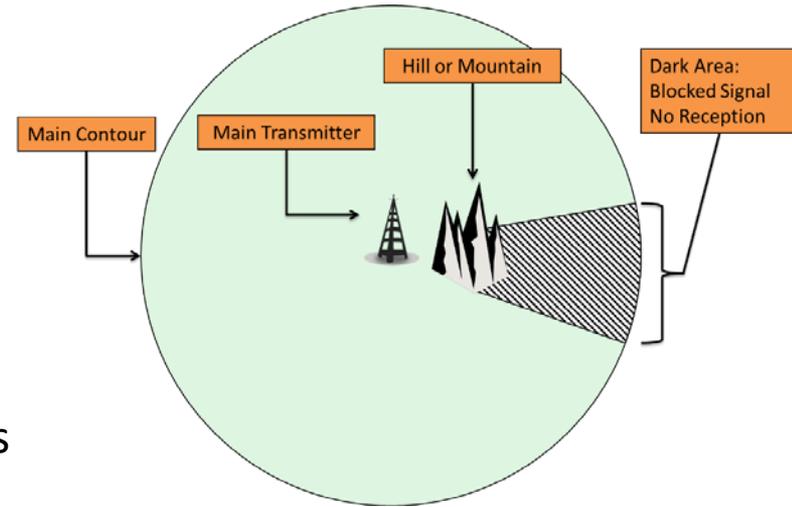
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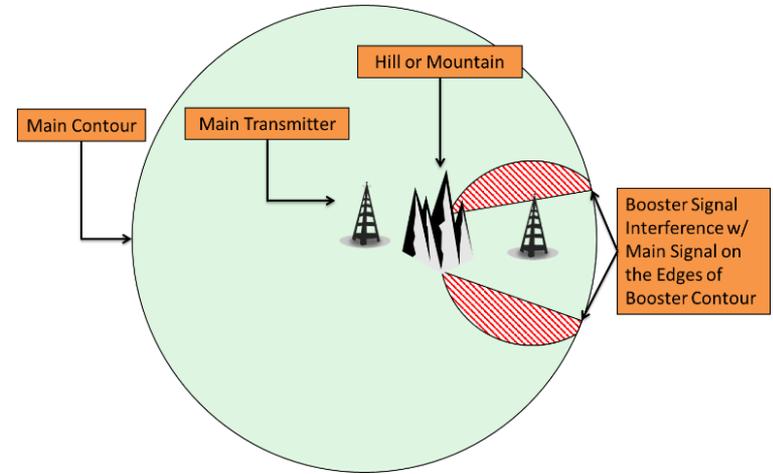
# Background

- FM overcame many reception issues that impacted AM broadcasting, however FM is generally a line of sight service.
- Ideally sited FM's have very good coverage typically from a tall tower or high mountain top, terrain such as mountains, ridges, or man-made structures such as city buildings cause shadows impacting usable reception.
- Sometimes stations attempt to serve a market from outside, commonly known as 'rimshots' whose protected contour may encompass the primary city desired but the signal, in reality, is not competitive.



# Background

- On-channel boosters or a single frequency networks to improve coverage due to signal impairment has been available for many years.
- The concept is simple - provide the same content on two (or more) different transmitters, locking to a common reference (typically GPS), creating seamless coverage.
- In practice, real-world results ranged from very good to the creation of new interference and impaired coverage thus many boosters have been turned off after many attempts to “dial it in.”
- The interference was caused by excessive overlaps of the main FM transmitter and the booster(s)



# What has changed

- Global digital radio and television standards and advancements of mobile telephony networks have furthered understanding of interaction between transmitters in a network, proper network design, and the criticality of system timing.
- Planning software has improved immensely.
- COFDM modulation makes single frequency networks simpler and more robust, many principles can be applied to analog FM, despite the single carrier nature.
- Technology evolution in IP networks and advances in RF device technology have allowed broadcast equipment manufacturers to make significant improvement in the size, cost and flexibility of transmitters and transport products.

# What Has Changed

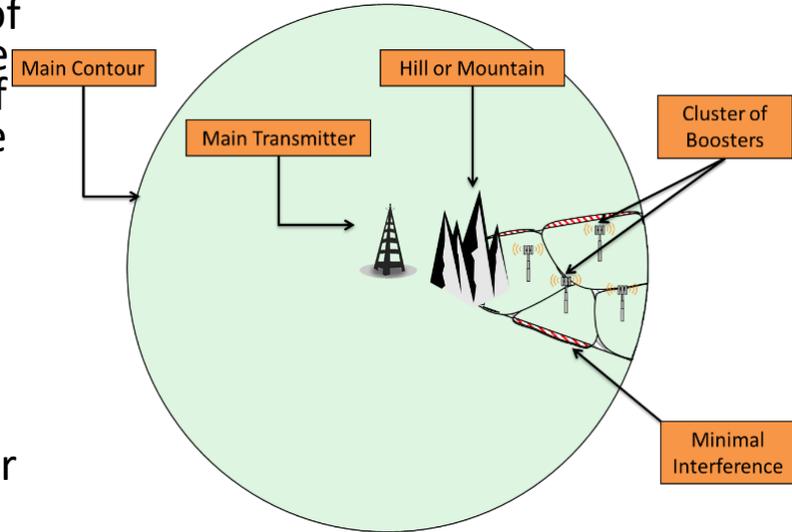
- The biggest change to implementing a successful SFN network is a shift to thinking about them as part of a planned network of RF sources like a mobile cellular network.
- The very principles that make a great FM main site - high placement of the antenna, great look angle to the intended market, broad coverage, maximum allowable power and so forth are very poor choices for a successful booster.
- The culmination of these changes requires a holistic view of optimizing coverage to meet each station's market, format, and listener demographics.
- Develop a technical system of carefully aligned design, equipment, and implementation rather than the traditional approach of selecting components based on brand preference coupled with local engineering team implementation.

# Importance of network design

- In many countries outside of North America, using multiple low power transmitters in an SFN to create a targeted coverage is commonplace, especially using DVB-T/T2 (television) and DAB/DAB+ (radio) modulations.
- This is also the case globally for mobile networks using GSM/LTE networks.
- Advances in network planning and coverage software from companies not normally seen in typical FM coverage analysis provide a critical tool needed to properly design a successful SFN network.
- These tools map interference at the RF level between multiple transmitter sites and assist crafting the antenna patterns for the booster sites to target the coverage and minimize interference.
- These tools also calculate the timing offset required between multiple boosters within a network based on the RF propagation delay from sites to overlap areas.

# Precision RF design

- GeoBroadcast Solutions pioneered the concept of multiple boosters employing mobile-cellular type antenna patterns to create a focused coverage of the desired area with little signal overlapping the main coverage – MaxxCasting™.
- Highly directional antennas with high front-to-back ratios are deployed in clusters focusing the RF energy specifically in the areas of desired coverage improvement.
- The relationship between antenna patterns, booster site selection, antenna elevation, booster ERP, directions of propagation and the related timing between the sites are just some of the variables that are analyzed and optimized to create seamless coverage.

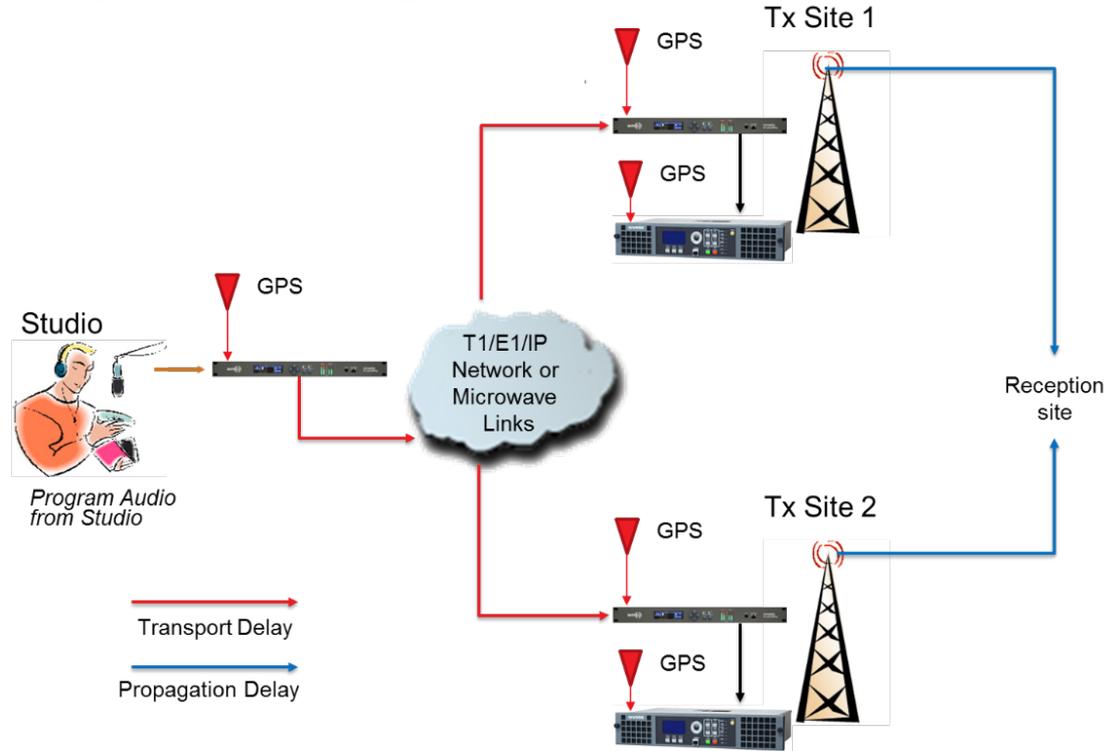


# System Timing

- In addition to the alignment of the frequency of each transmitter, the audio path needs precision alignment to ensure simultaneous arrival of the audio at the receive sites in the overlap area where a receiver would be getting signal from two or more transmitters.
- GatesAir's Intraplex SynchroCast® system employs patented technology that provides real time adaptive delay to maintain precision control in an SFN system.
- The first delay that needs to be managed is the transport delay which accounts for the time to get the audio to each transmitter site using a variety of methods.
- The second major type of delay that needs to be managed in an SFN system is the propagation delay of the RF signal from each transmitter site to the area of overlap.

# System Timing - Typical System Diagram

- In addition to the two major delays, each piece of equipment in the signal path such as the exciter has delay that needs to be accounted for
- It is best to use identical equipment to eliminate variability and unknown delays
- The overall delay for each site will be different to account for all parameters and will be no shorter than the maximum delay of the longest transport path and propagation path plus some buffer to allow for the real time adaptive time control.



# Why Delay Matters

- Whenever more than one co-channel signal reaches an analog receiver, not in perfect alignment, heavy multipath at best and signal cancellation at worst will occur. It can create an unlistenable signal.
- Signals may be in perfect phase and synchronization in one particular location; a few kilometers away – not so!
- Various items impact tolerance - talk versus music programming, mono, or stereo, etc.
- As the amplitude becomes closer to equal, timing is more critical. Noticeable interference manifests itself with as much as a 20dB d/u when synchronization is improper.
- Proper design will mitigate or even eliminate interference. Exact synchronization of the audio phasing, modulation levels, pilot, and carrier frequency are always necessary.
- All exciters in the network should be identical or ensure that the modulation components & internal latency is compensated or synchronization will be impossible.

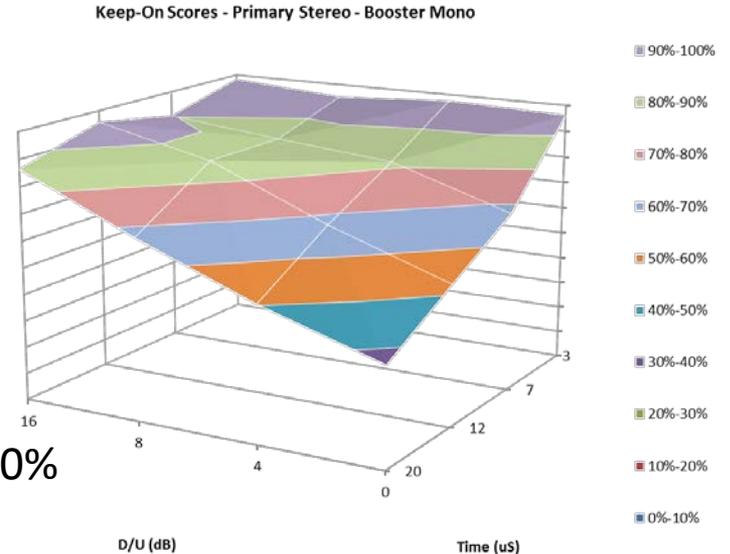
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# Why Delay Matters

- Listening tests conducted by NPR Labs and Towson University revealed for the first time, what listeners would tolerate in terms of misalignment under a wide variety of conditions.
- This drives the customized software for network design, using real-world data.
- Listeners Evaluated:
  - Mono and stereo modes
  - Speech, music, voiceover
  - Time-of-arrival between signals
  - RF ratios between signals
  - Compiled as tables, then surface charts
  - All to determine “Keep On” score – we target 90%
  - 533 samples/19,000 datapoints



# Choices in transport

- Options for audio transport to transmitter sites have become more flexible
- Migration from TDM to IP transport increases flexibility in links as has further development of audio data compression CODECS.
- GatesAir Intraplex® IP Link with SynchroCast® technology provides the needed program transport and precision timing control enabling seamless coverage that today's booster systems demand.
- The IP Link can transport analog and digital discrete L/R audio using a full range of compression and error mitigation options tailored to available network capacity. The MPX version transports both analog and digital AES192 composite MPX audio.
- This significant breakthrough for SFN applications eliminates the use of multiple aligned stereo generators at transmitter sites and allows use of a single stereo generator in the main processor. This ensures the identical signal is delivered and time aligned for each transmitter site.



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# Limited connectivity – No Problem

- If IP connectivity is an issue at your current or potential site, you no longer need to eliminate a site as a possible booster location
- GatesAir Intraplex HD link, a 950mHz STL system, can also support SynchroCast technology and is ideal for sites with limited wired connectivity.
- HD Link can be mixed and matched with IP links in a single network.
- Wireless IP radios in both the licensed and unlicensed bands can be deployed to support SFN operation. The SynchroCast technology automatically adapts to the non-deterministic nature of these radios and continue to deliver reliable, perfectly timed audio.



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# Simplified Transmission



- FM broadcast transmitters have evolved over the years, recently converging the capability of digital FM exciters, integrated GPS receivers, IP based monitoring/control and the latest 50-volt LDMOS technology.
- GatesAir Flexiva FAX line of solid-state, digitally modulated FM transmitters offer high power density and a very compact footprint. The FAX 3.5K can produce up to 3850 watts in a small 4 rack units of space and weighs a mere 56 lbs./25 kg.
- The combination of technology, integrated capabilities such as GPS, and the world-class digital exciter well supports SFN boosters in today's space constrained environments.

# Synchronizing Translators

- Boosters under Part 74 FCC rules are located **INSIDE** an FM station's protector contour
- Translators are using the same technology but are **OUTSIDE** the station's protected contour.
- The translator is co-channel (same channel) with the main station and is used to extend coverage beyond the station's contour, something a booster is not permitted to do. Typically, they are fed by another station's HD Multicast (HD2, HD3, HD4).
- In all ways, the technology being used is identical to boosters inside the contour.



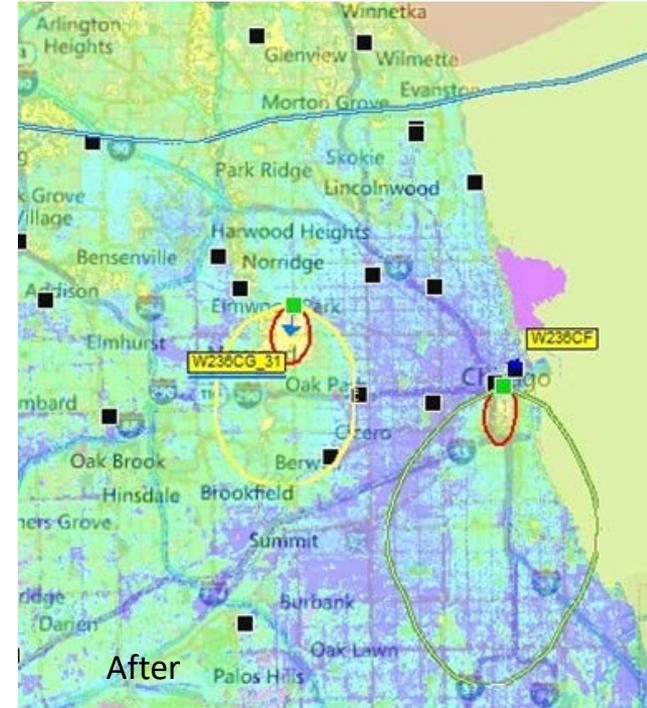
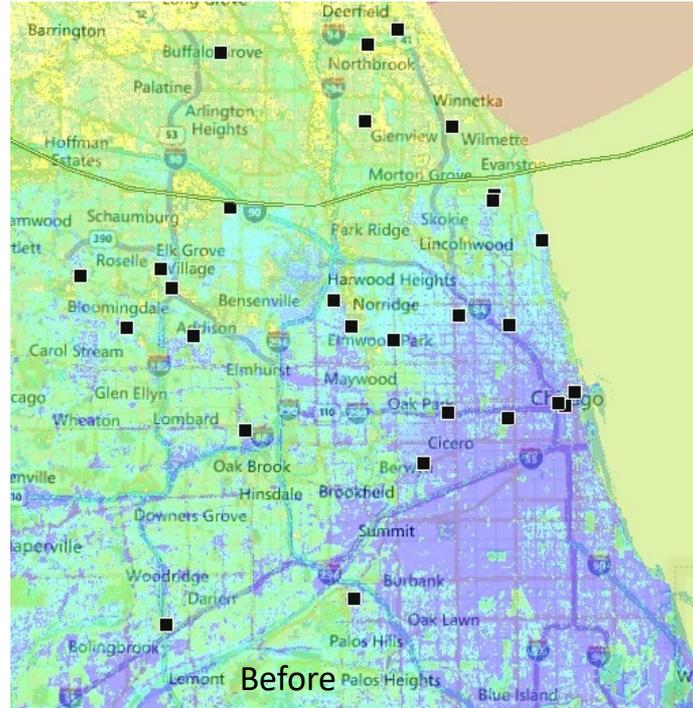
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# Synchronizing Translators

- Measurements on station WILL, Union Grove, WI are an example of co-channel translator implementation.
- Two co-channel translators are situated south of the main station's contour to serve portions of the Chicago market.



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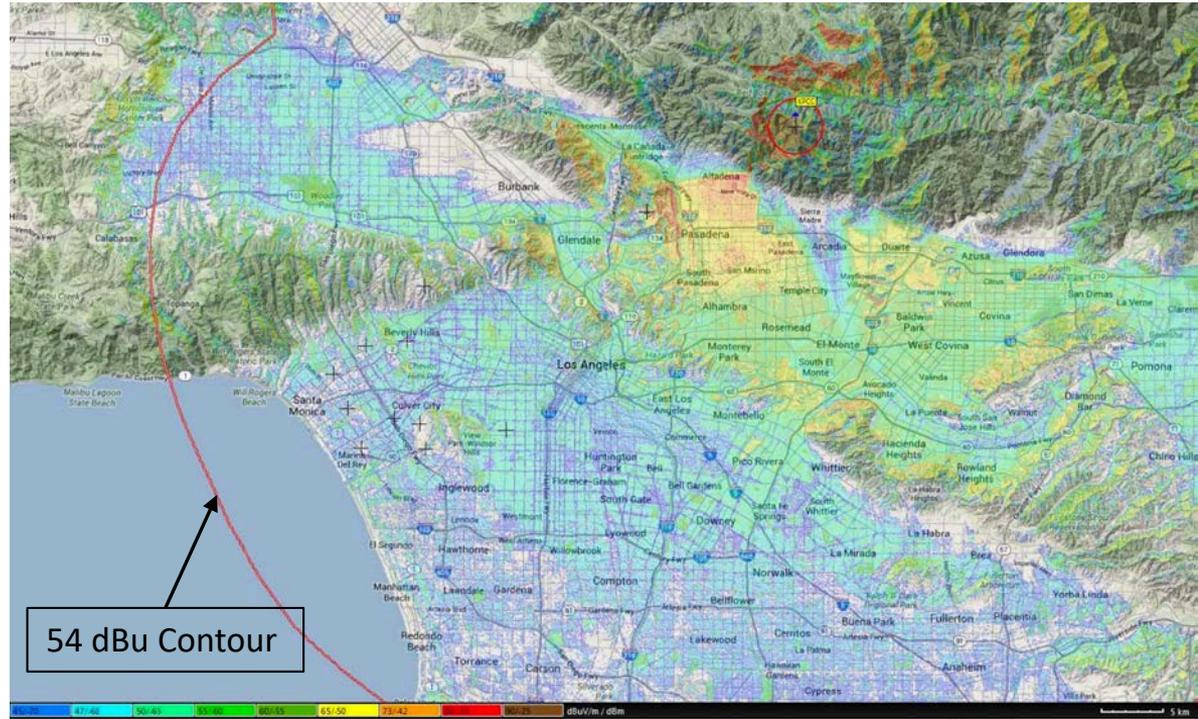
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# Case Study (MaxxCasting) – KPCC Los Angeles, California

- Current Coverage

KPCC Channel: 207-B 89.3 MHz

- Licensee: Pasadena Comm. Coll.  
City of License: Pasadena, CA.  
Effective Radiated Power: 0.6 kW  
Antenna Center HAAT: 891 m  
Omni-Directional Antenna



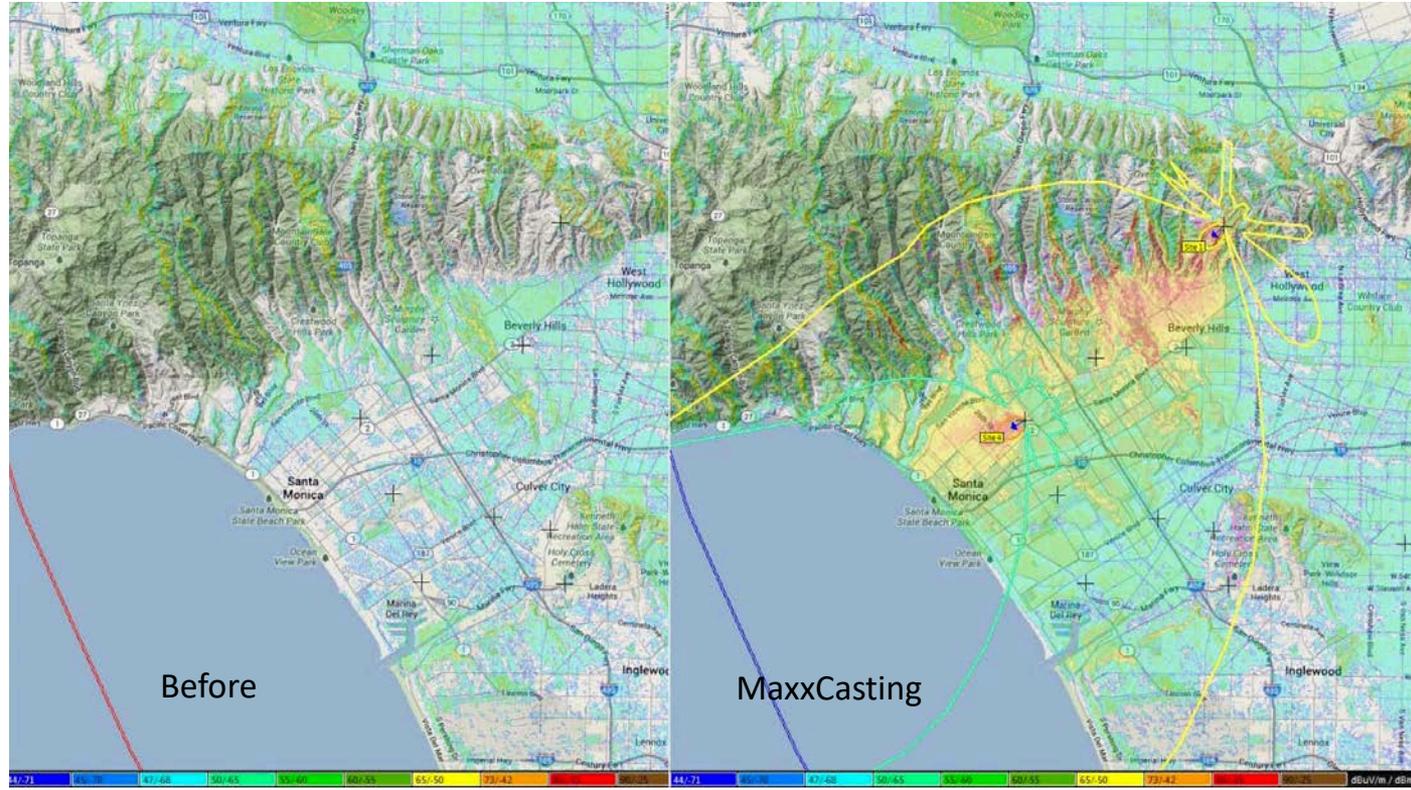
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# Case Study - KPCC

- KPCC is on Mt Wilson, a very tall mountain outside of Los Angeles.
- However, the 600 Watts ERP does not provide good coverage despite the wide contour

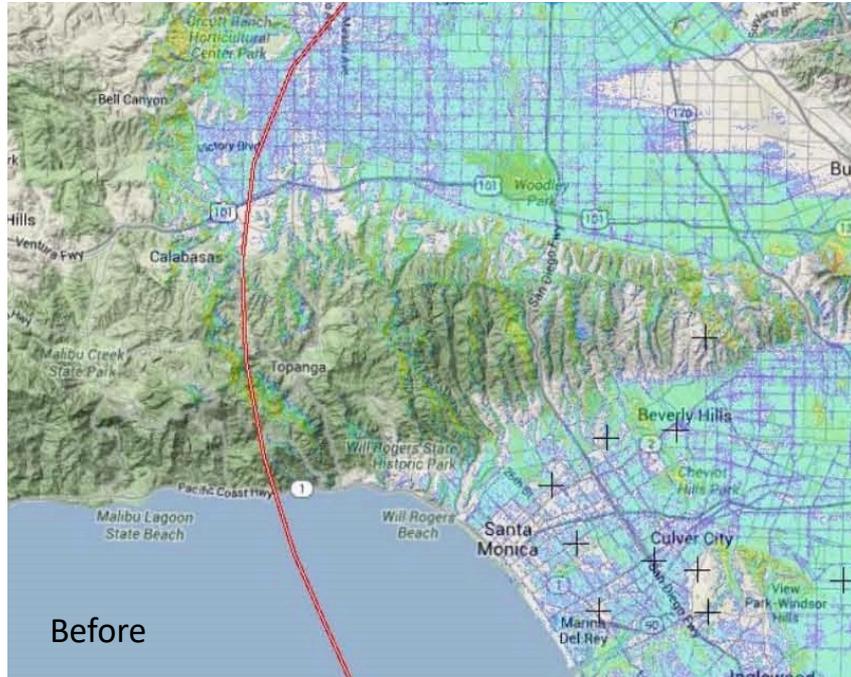


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# Case Study - KPCC



- Coverage into the all-important Malibu area was virtually non-existent. With MaxxCasting, significant coverage is available. Even though this is fully FCC compliant, KPCC's coverage extended well past the contour, in this case (over water).

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# KPCC - What are the results?

## #2 Los Angeles

February 2018 Portable People Meter 6+ Mon-Sun, 6a-12mid (Updated: 03-19-18)  
12+ Population: 11,465,400 (Black: 815,200) (Hispanic: 4,900,100) Surveyed: Continuously

Station	Dec 17	Hol 18	Jan 18	Feb 18	Format	Owner
KPCC-FM	2.5	2.4	2.8	3.0	News	Pasadena Area Community College



- KPCC was running 1.3 - 1.5 AQH prior to implementing boosters with MaxxCasting in April 2017
- #11 now – had been #22 out of 47 Stations reporting
- KPCC is a 600 Watt NPR station

# Case Study (MaxxCasting) - WXRV

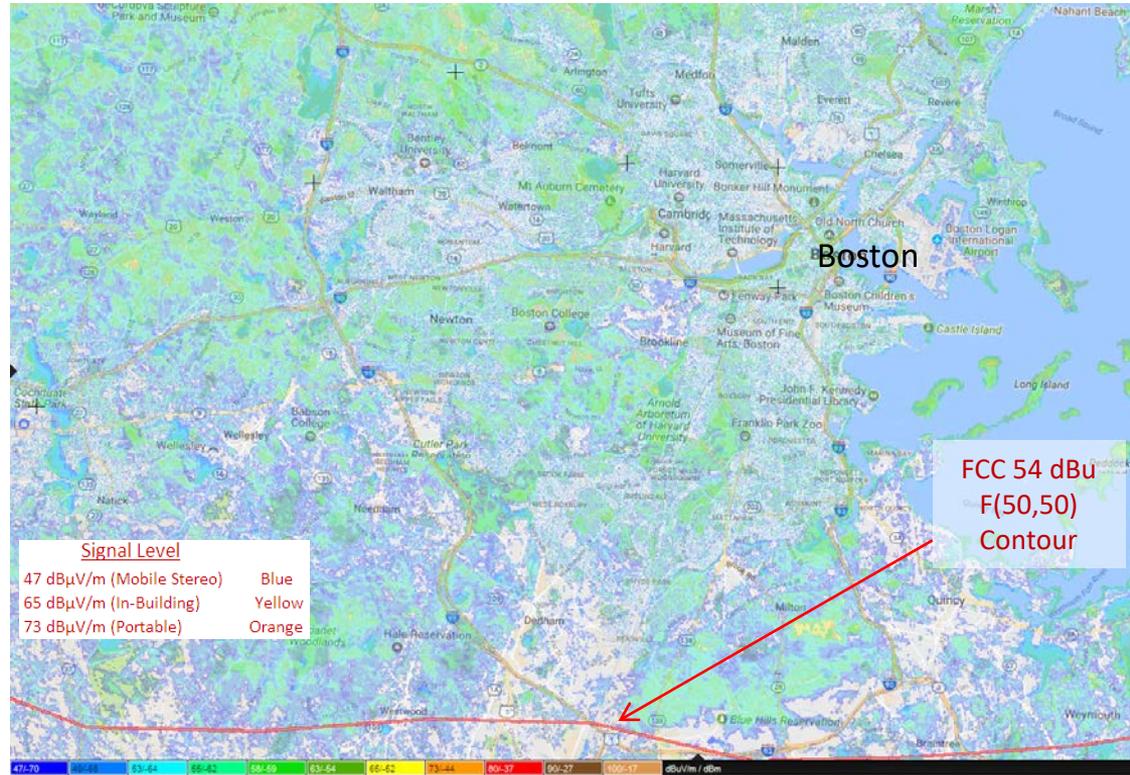


- Current Coverage

WXRV Channel: 223-B 92.5 MHz

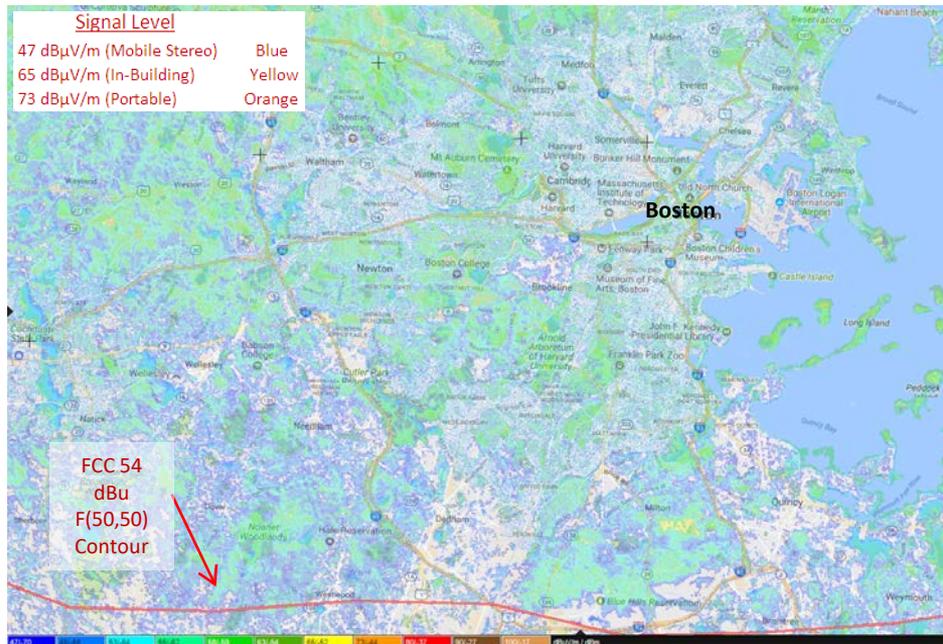
- Licensee: Northeast Broadcasting  
City of License: Andover, Mass.  
Effective Radiated Power: 25 kW  
Antenna Center HAAT: 217 m  
Omni-Directional Antenna

WXRV is a “rimshot” station from about 20 miles north of Downtown Boston. Downtown signal is compromised by strong high-power local FM transmitters and partial terrain blockage and signal in important western suburbs was spotty.

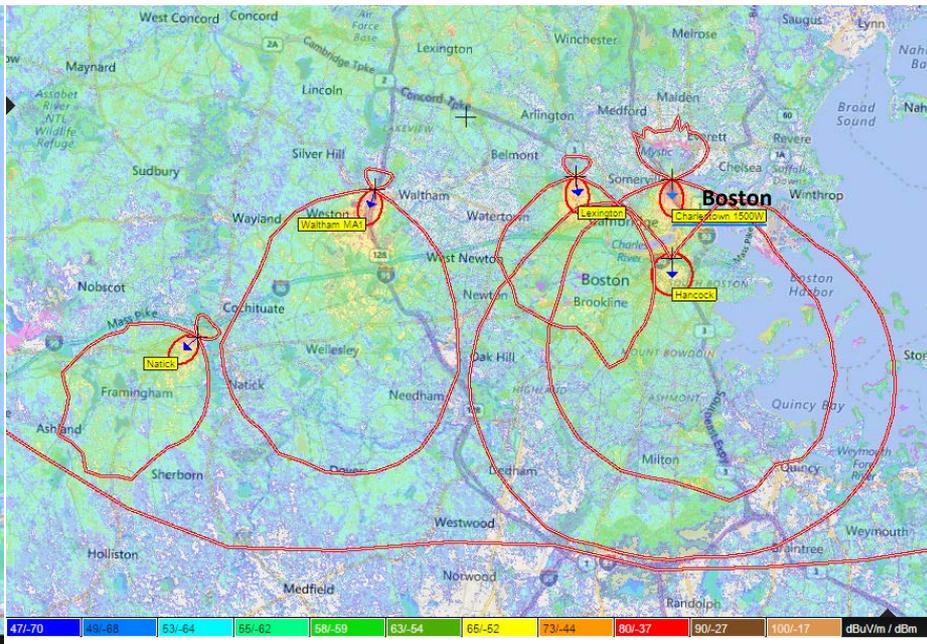


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# WXRV MaxxCasting Design



Before MaxxCasting



Five MaxxCasting Nodes

Geo Broadcast Solutions, LLC-- Confidential Proprietary

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# How does it work – A GM's perspective

To: Chris Devine  
Cc: 'Gary Hammond'  
Subject: WXRV/92.5 the River and MaxxCasting

Chris,

Just a quick note to give you my anecdotal listening critique of the MaxxCasting coverage and transitional listening experience between WXRV's main tower/antennae and our 4 new boosters (Natick, Waltham, Lexington and the Hancock Tower).

The only way to know if you're listening to the main or a booster is by looking at your car radio RDS display (as you know - we do not currently have artist/title displayed on the boosters). The experience of listening to the main as it transitions to the various boosters is seamless and undetectable. The average listener would have absolutely no idea. The benefit is obvious - WXRV's signal has improved substantially in areas that had been previously impaired for a variety of reasons. The station's signal off the Hancock Tower south of Boston sounds robust and very resonate, without interference and static. I plan to spend much more time on the surface roads to examine the signal more fully, but my initial listening experience has been outstanding.

More details to follow!

My best,

Donald St. Sauveur  
General Manager  
WXRV/92.5 the River

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# WXRV – Boston – Results

- Prior to MaxxCasting, WXRV was typically at a 1.5 AQH share, 6+ Monday – Sunday 6 am to Midnight, always bested by direct competitor WBOS-FM.

[Market Profile](#) | [New Listings](#) | [Alphabetical Listings](#) | [Market Rank Listings](#) | [PPM](#) | [Arbitrends](#) | [Menu](#)

## #10 Boston

November 2017 Portable People Meter 6+ Mon-Sun, 6a-12mid (Updated: 11-30-17)  
12+ Population: 4,238,000 (Black: 319,200) (Hispanic: 428,500) Surveyed: Continuously

Station	Aug 17	Sep 17	Oct 17	Nov 17	Format	Owner
WXRV-FM	1.9	1.7	2.1	2.1	AAA	River Radio Network
WBOS-FM	2.1	1.9	1.7	1.8	Alternative	Beasley Media Group

## #10 Boston

February 2018 Portable People Meter 6+ Mon-Sun, 6a-12mid (Updated: 03-20-18)  
12+ Population: 4,294,800 (Black: 338,700) (Hispanic: 461,700) Surveyed: Continuously

Station	Dec 17	Hol 18	Jan 18	Feb 18	Format	Owner
WXRV-FM	1.9	1.6	2.1	2.1	Alternative	River Radio Network
WBOS-FM	1.6	1.8	1.8	1.9	Alternative	Beasley Media

With MaxxCasting, WXRV now consistently beats its head-to-head competitor WBOS

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# It more than just casual observation – Impact on PPM

- Watermarking (PPM) is affected by Signal Quality
- A PPM signal, sent by the encoder in a poor RF environment (low level, multipath, interference) often does not get decoded by the Portable People Meter (PPM).
- “If the PPMs aren’t decoding, you might as well be off the air.”
- 25-Seven has developed the Voltair processor and the TVC-15 Watermark Analyzer & Monitor (real-time analysis) to improve & monitor PPM encoding.

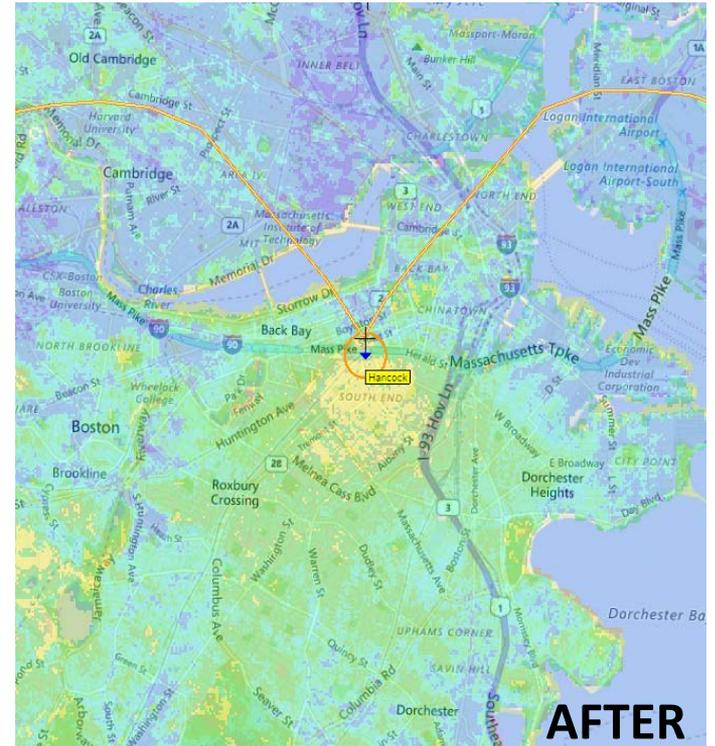
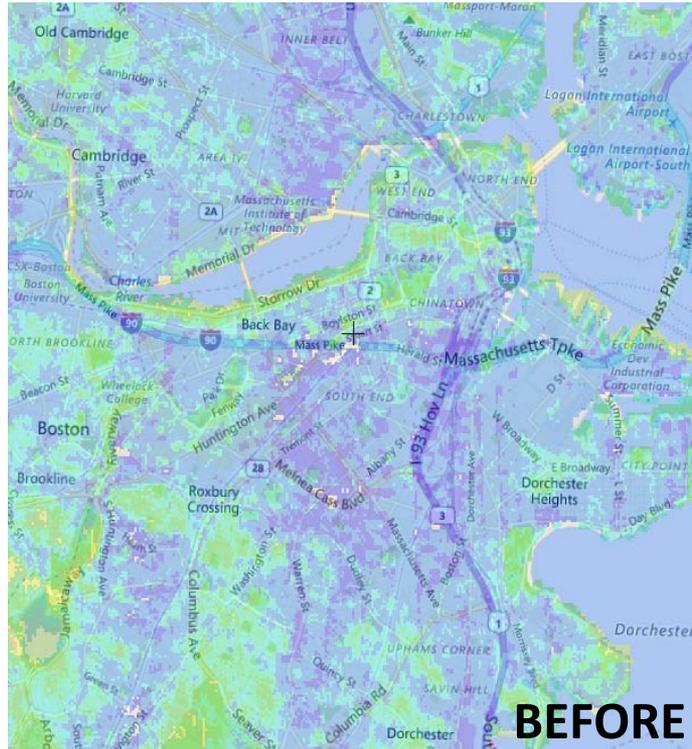


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# WXRV Boston Hancock Building Node Analysis



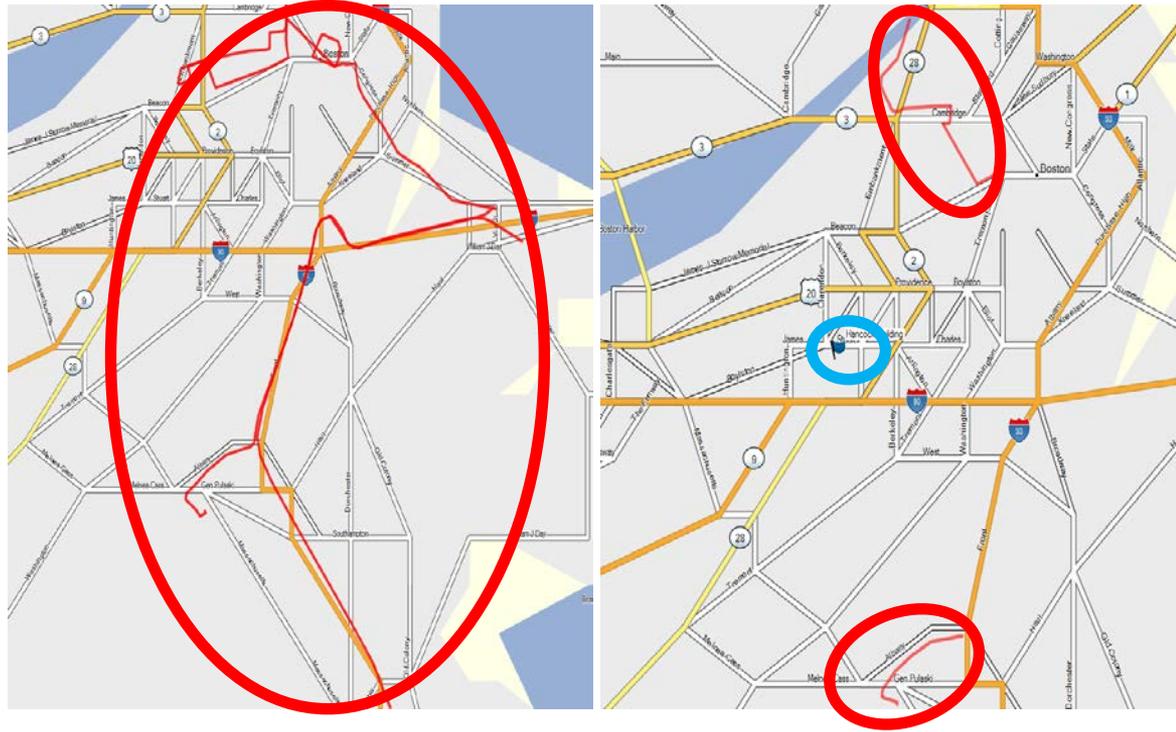
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# Field Measurements and Observations

- **RED ROUTE** indicates >30 Seconds of a minute of missed messages (Loss of Quarter Hour)
- Watermarking (Ratings) are significantly affected by Signal Quality
- Watermark decoding potential improves significantly (>6 out of 12 MSG/MIN) with the Hancock Booster Node ON
- This correlates to a 17% increase in Quarter-Hour Ratings for a single node
- Nielsen ratings have shown substantial improvement



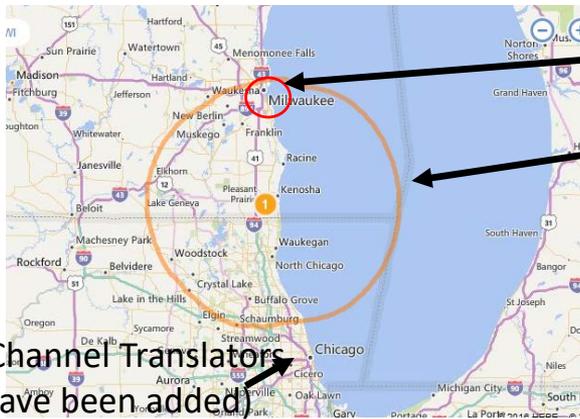
# Another form of Booster Use – ZoneCasting™

- Traditionally, boosters have been used to mitigate signal problems within an FM station's protected contour and have thus presented identical programming to the main FM transmitter.
- GeoBroadcast Solutions has developed, patented and branded ZoneCasting which has a different purpose – to divide an FM station's coverage area into two or more “zones” where the boosters would play out separate content from the main FM signal for certain portions of an hour or even hours in a day.
- In the fall of 2016, a 3<sup>rd</sup> technical trial was authorized by the FCC in Milwaukee, WI over station WIIL (Union Grove, WI). Portions of downtown Milwaukee were separated from the main station's signal to form a zone where separate programming could be aired.



# MaxxCasting vs ZoneCasting

- MaxxCasting is 100% SIMULCAST of the main station
- ZoneCasting sets up one or more INDEPENDENT zones with SEPARATE programming from the main
- In Milwaukee, BOTH are used in a hybrid system
- Both technologies are Patented

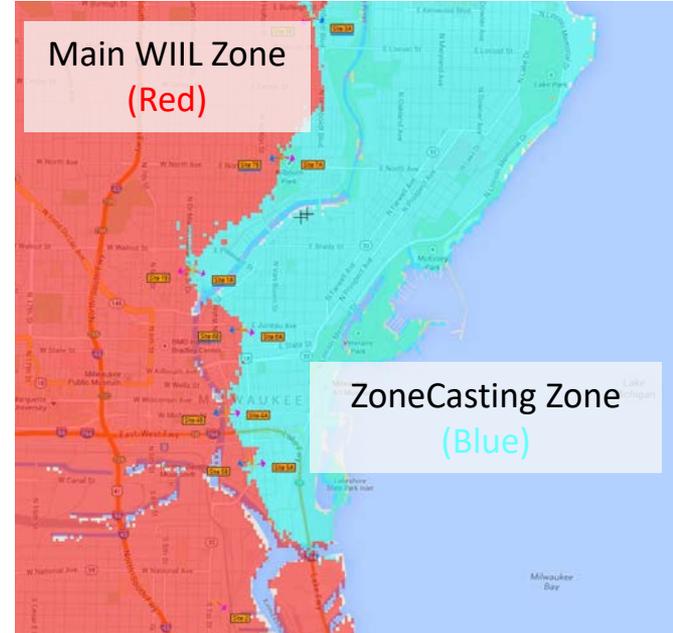


Area of interest

WIIL 54 dBu Contour

WIIL Union Grove, WI  
Alpha Media  
Channel 236B (95.1 MHz)  
50 kW @ 117 m HAAT

Co-Channel Translators  
(have been added)



Main WIIL Zone  
(Red)

ZoneCasting Zone  
(Blue)

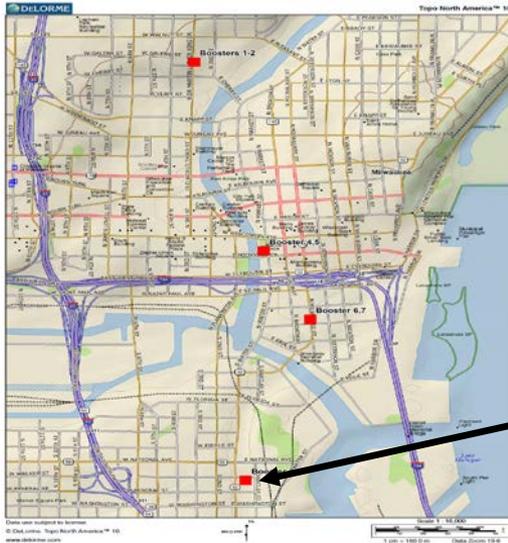
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# Why Hybrid?

- Main signal in Downtown Milwaukee was very poor/unlistenable – to create listenability
- To create “sharp edges” of delineation (D/U ratio) between main signal and zone to minimize interference



Site locations shown (7 nodes, 3 common sites)

Antennas pointing both East and West  
West is MaxxCasting, East is ZoneCasting

Exception – southernmost node is strictly MaxxCasting (1 antenna) to help “set off” the zone and separate it from the main to the south

# The Nodes

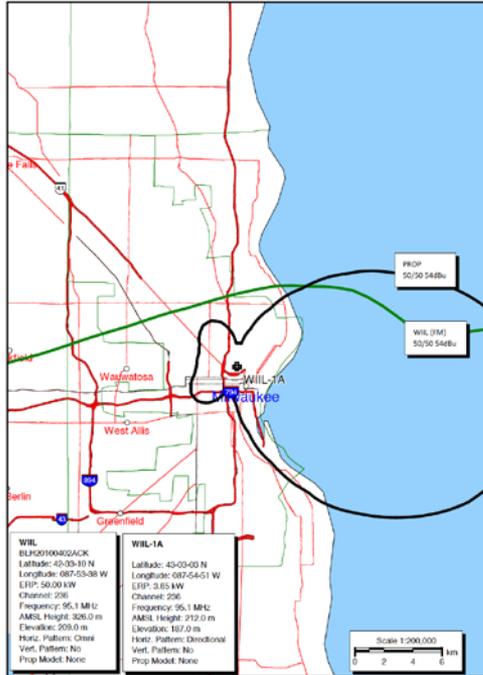
FCC Rules permit boosters to operate up to 20% of main FM class power

Site #	Location	ERP	Height AGL (M)	Orientation
1	Brewery Works A N Milwaukee	3.65 kW	25	100°
2	Brewery Works B N Milwaukee	.255 kW	25	250°
3	SBA Tower	5.00 kW	30	140°
4	Downtown A Rooftop	.200 kW	89	85°
5	Downtown B Rooftop	.400 kW	89	252°
6	Phoenix Building A	1.50 kW	25	85°
7	Phoenix Building B	1.00 kW	25	250°

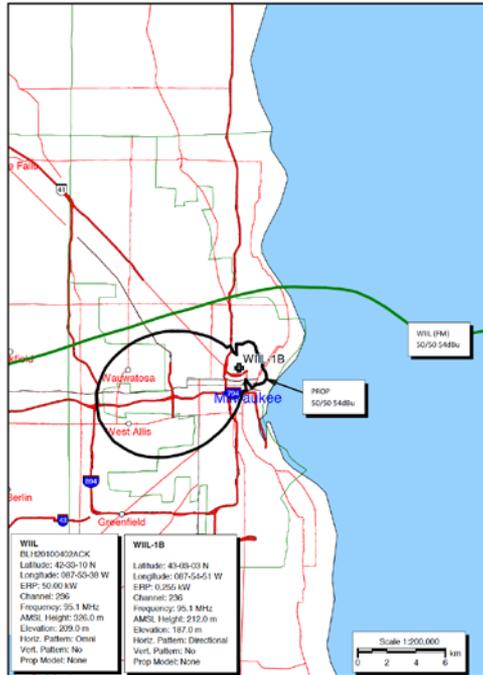
Zone power levels are designed to cover the desired area and to minimize interference

# The Nodes

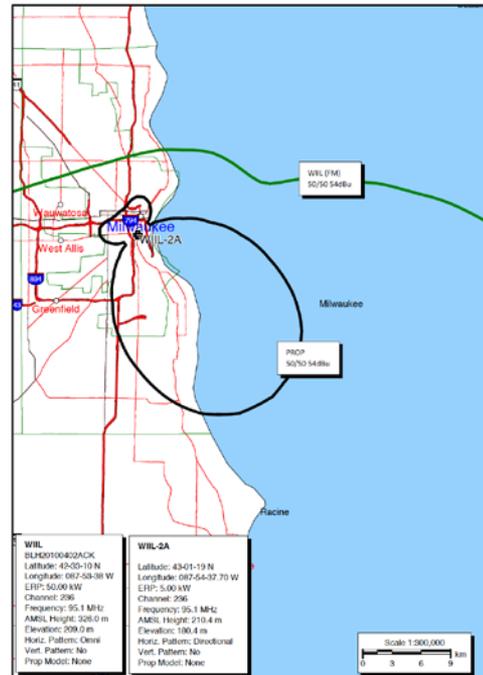
WIIL LIC 150/50 54dBu Protected Contour Vs. PROP "Brewery Works" A



WIIL LIC 150/50 54dBu Protected Contour Vs. PROP "Brewery Works" B



WIIL LIC 150/50 54dBu Protected Contour Vs. PROP "SBA Tower" ASR 1060030

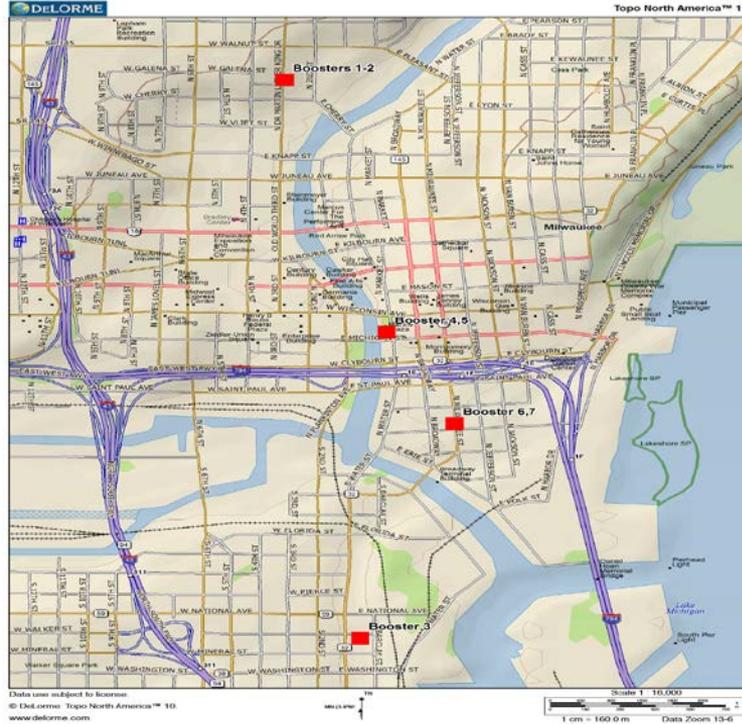


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# Antenna Orientation



A total of 7 nodes via 6 sites

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# Milwaukee Site Pictures

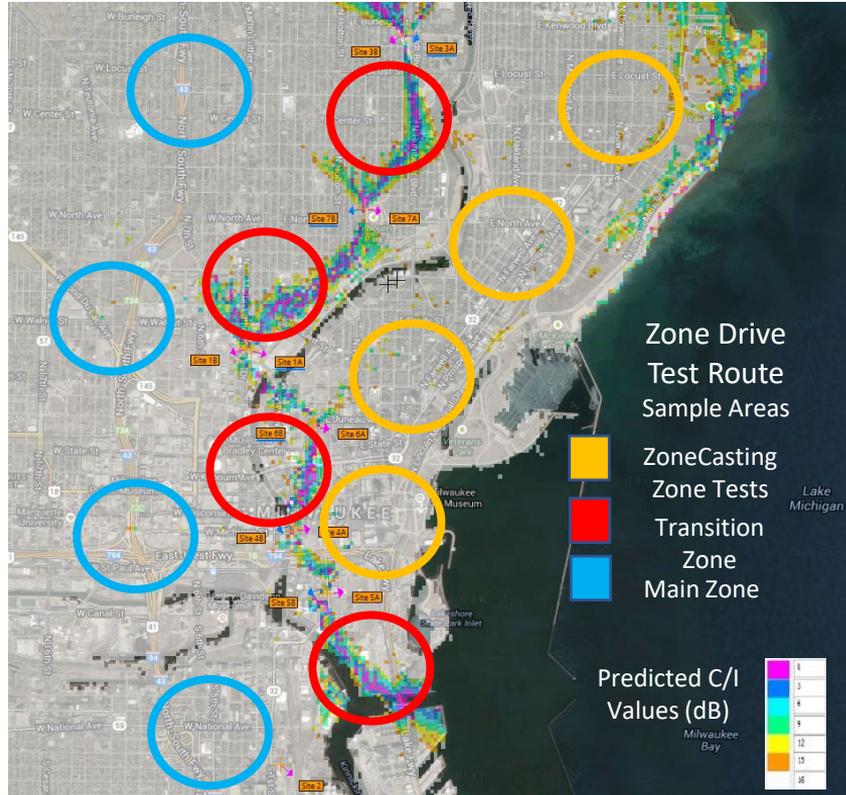


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# Zone Drive Test



- In reality, the entire city area has been driven
- Measurements & audio samples retrieved
- Report filed with FCC for NPRM



"In Milwaukee County, we saw a significant audience increase in males 18 and over from October to November. This is an important demographic for our Active Rock format, and we can directly attribute this increase to the MaxxCasting network lighting up more PPM units," said Karl Wertzler, WIIL general manager.

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# Conclusion

- Radio is, at its heart, local, mobile, and free - all excellent value propositions.
- However, if your listeners can't receive your station, even the best value proposition will fail.
- While the potential for FM boosters and SFN networks have long been regulatory options, the reality of a useful deployment escaped many who tried and resulted in years of belief that “boosters just don't work.”
- Today's advances in technology and system design capabilities prove boosters not only work, and work well, they can be an important tool for increased coverage, improved listener experience and better ratings.
- The ability to impact listeners and ratings translates to new revenue opportunities and improved profitability for broadcasters.