



FM SFN NETWORKS 2.0

RICH REDMOND

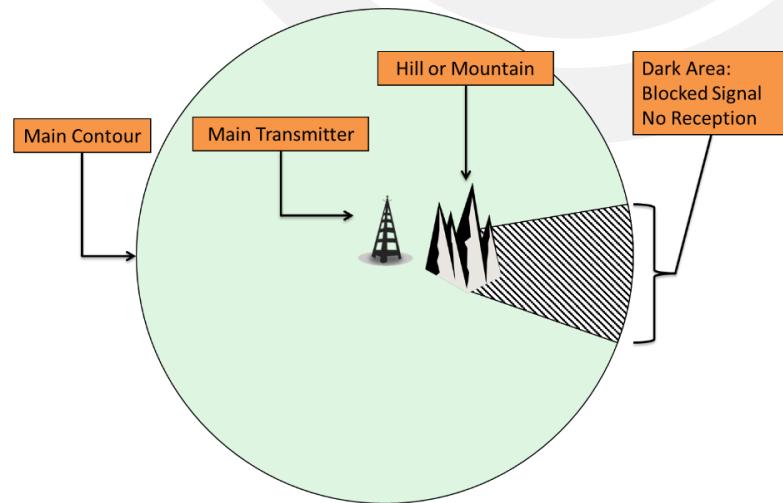
PRESIDENT/MANAGING DIRECTOR - INTERNATIONAL



GATESAIR® BACKGROUND

VIRTUAL events

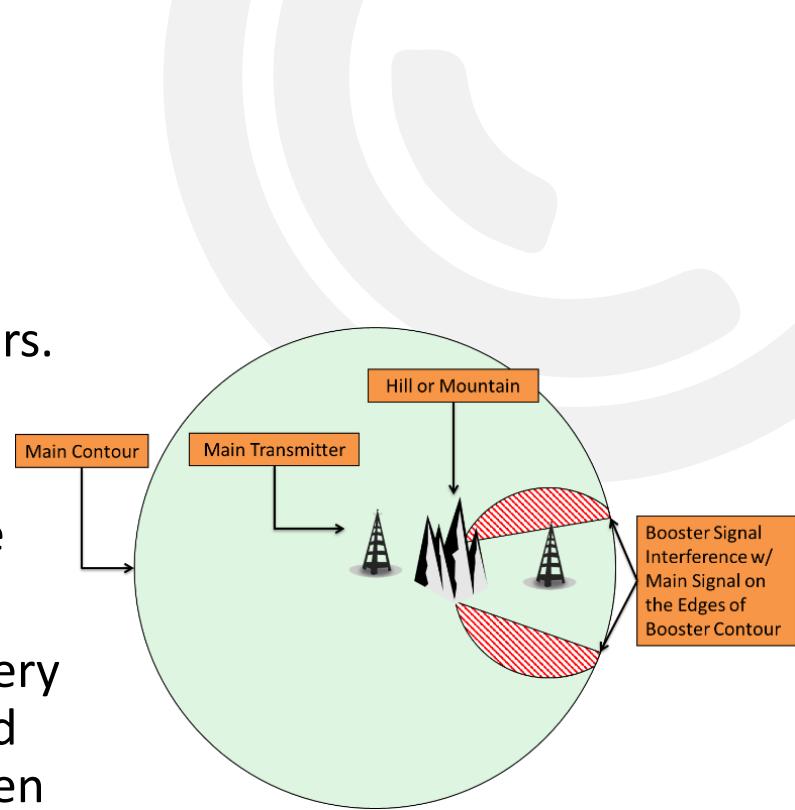
- FM overcame many reception issues that impacted AM broadcasting, however FM is generally a line of sight service.
- Ideally sited FM's have very good coverage typically from a tall tower or high mountain top, terrain such as mountains, ridges, or man-made structures such as city buildings cause shadows 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.



GATESAIR® BACKGROUND

VIRTUAL events

- 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 SFN's 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 SFN nodes.



WHAT HAS CHANGED

- Global digital radio and television and mobile phone networks have furthered understanding of interaction between transmitters, proper network design, and the criticality of system timing. Many principles can be applied to analog FM, despite the single carrier nature.
- Planning software has improved immensely.
- 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.
- 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 phone network.



GATESAIR® VIRTUAL events

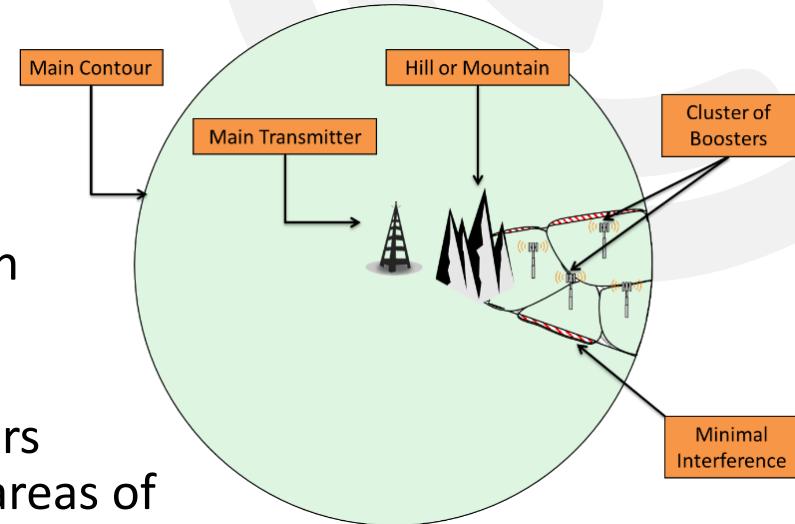
WHAT HAS CHANGED

- 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 FM SFN booster node.
- The culmination of these changes requires a holistic view of optimizing coverage to meet each station's market, format, and listener demographics.

IMPORTANCE OF NETWORK DESIGN

- In digital networks 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.
- 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. ADTI - HTZ communications.
- 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.

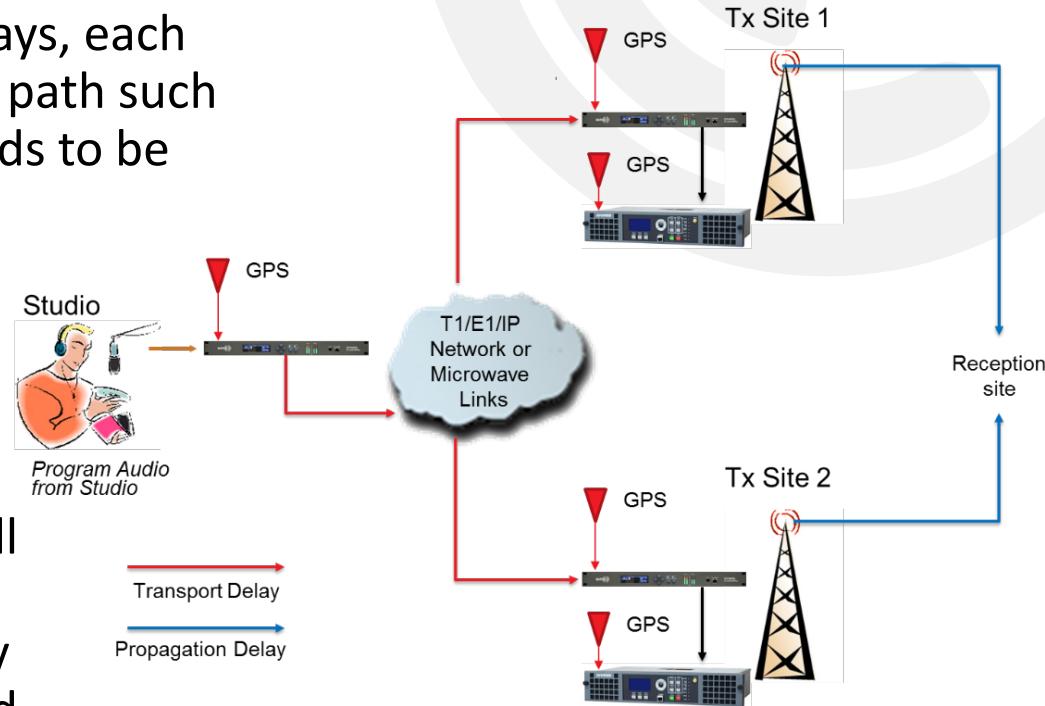
- GeoBroadcast Solutions pioneered the concept of multiple boosters employing mobile-cellular type antenna patterns to create a focused coverage of the desired area with little signal overlapping the main coverage – MaxxCasting™.
- Highly directional antennas with high front-to-back ratios are deployed 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.



- 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.



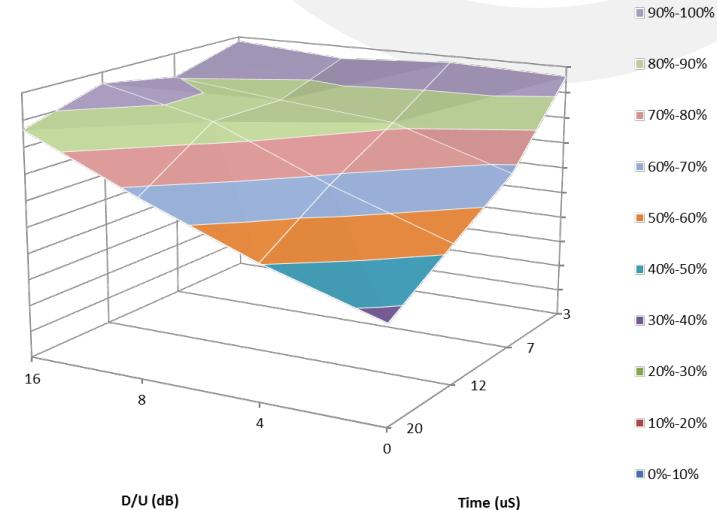
WHY DELAY MATTERS

- Proper design will mitigate or even eliminate interference. Exact synchronization of the audio phasing, modulation levels, pilot, and carrier frequency are always necessary.
- All excitors in the network should be identical or ensure that the modulation components & internal latency is compensated, or synchronization will be impossible.

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

Keep-On Scores - Primary Stereo - Booster Mono



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.
- Intraplex IP Connect will provide precision transport of HD Radio E2X.

CHOICES IN TRANSPORT

- This significant breakthrough of using MPX 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.
 - Recent operating Syncrocasts in New Zealand were upgraded from L/R audio to MPX and showed significant network performance improvement, more seamless overlap zones and a better listener experience.



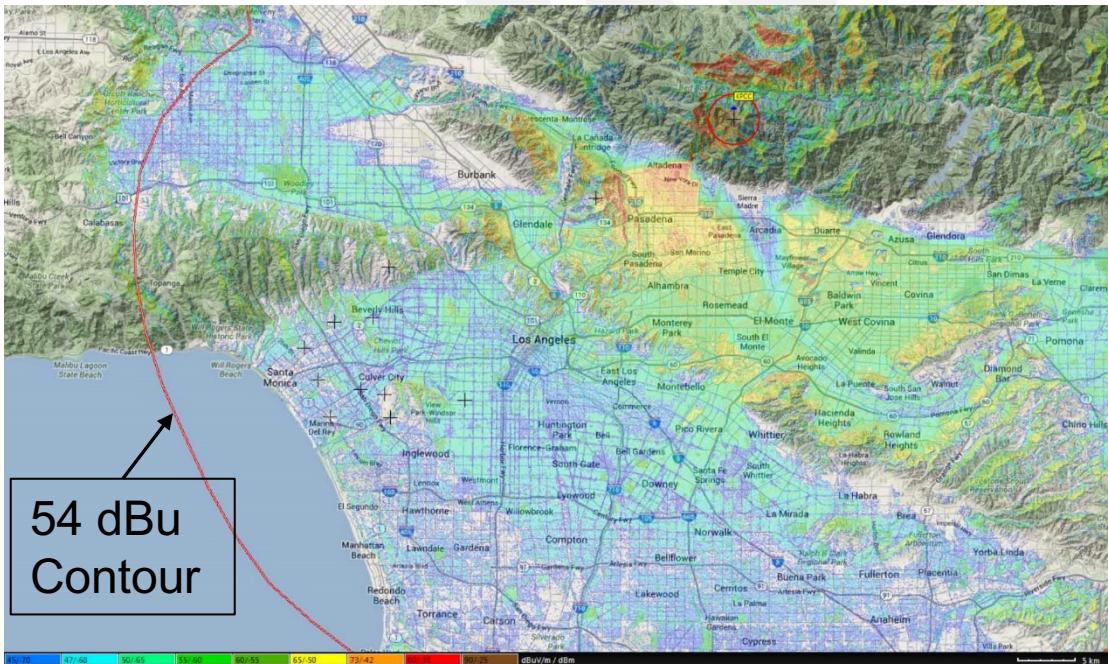
SIMPLIFIED TRANSMISSION

- FM broadcast transmitters have evolved over the years, recently converging the capability of digital FM excitors, 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.



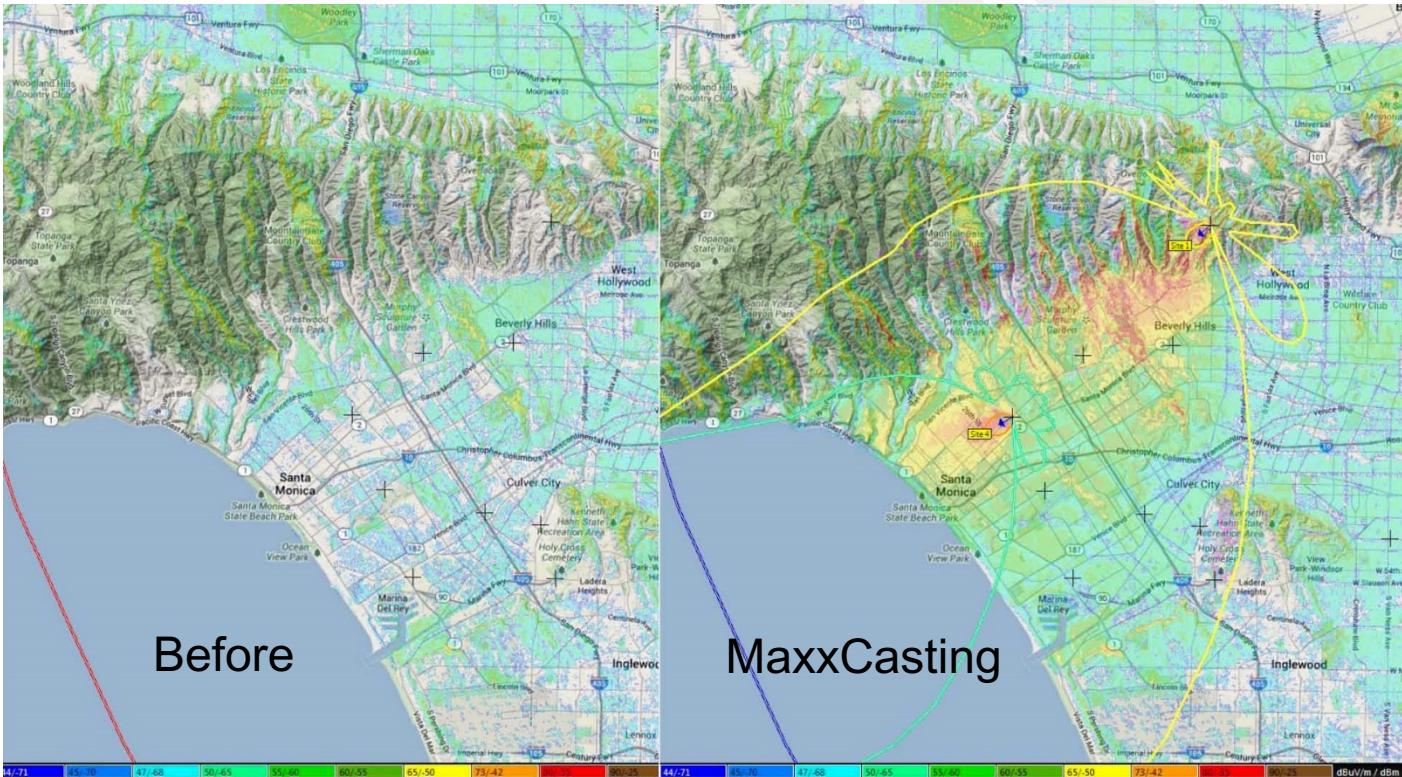
CASE STUDY – KPCC LOS ANGELES, CALIFORNIA

- 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



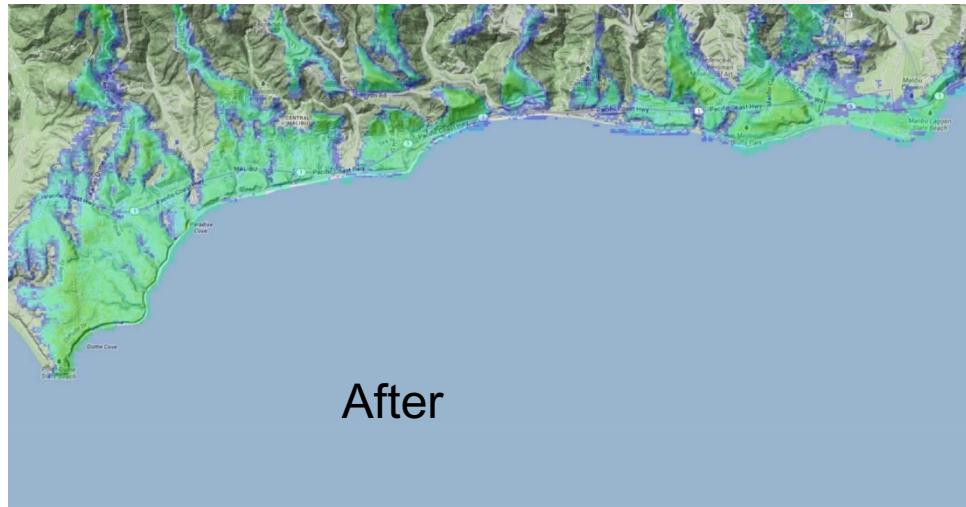
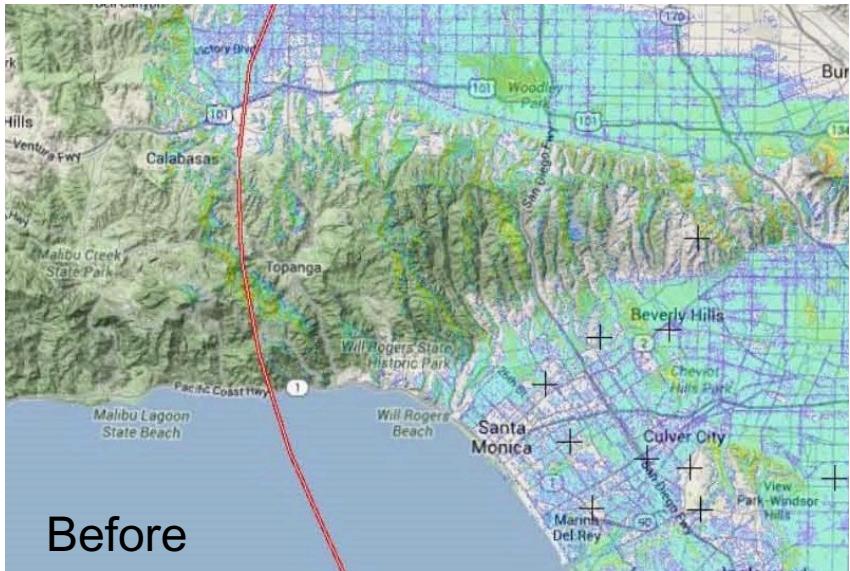
CASE STUDY – KPCC LOS ANGELES, CALIFORNIA

- 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.



CASE STUDY – KPCC LOS ANGELES, CALIFORNIA

- 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).



KPCC - WHAT ARE THE RESULTS?

- 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

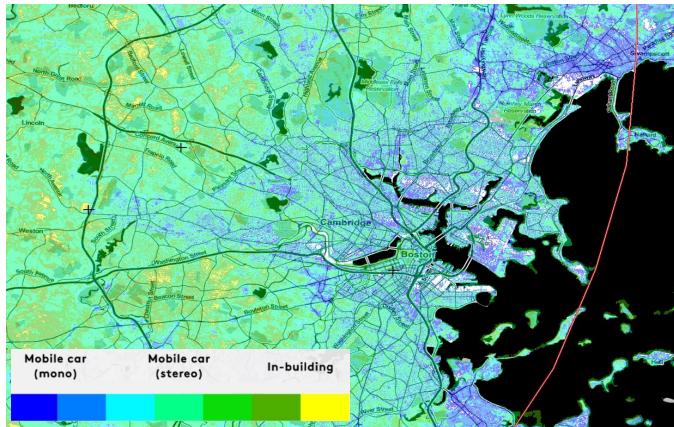
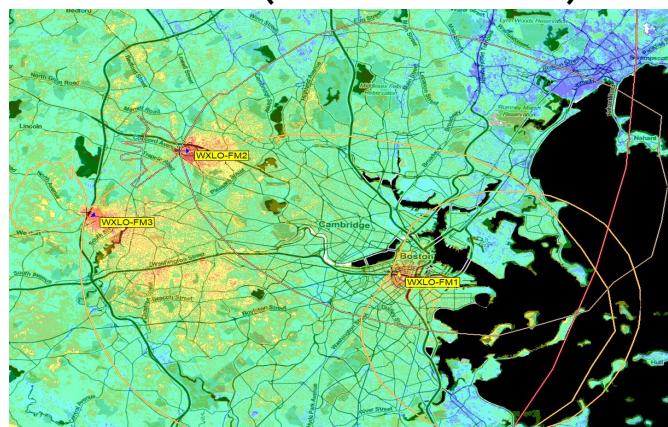
#2 Los Angeles

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

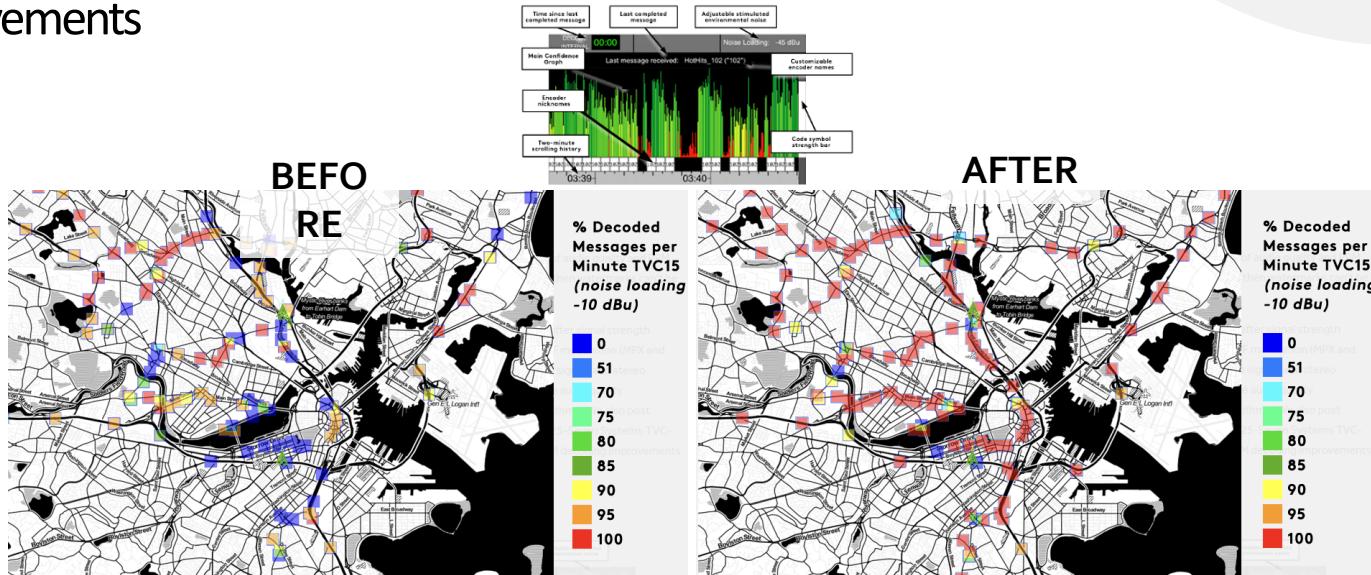


- Cumulus WXLO-FM
- 37 kW Class B station 40 miles west of Boston
 - A “Worcester” market station (#121)- Now in Boston (#10)
 - Radio Screen Geo-Targeting (today)
 - Audio Geo-Targeting candidate (tomorrow)

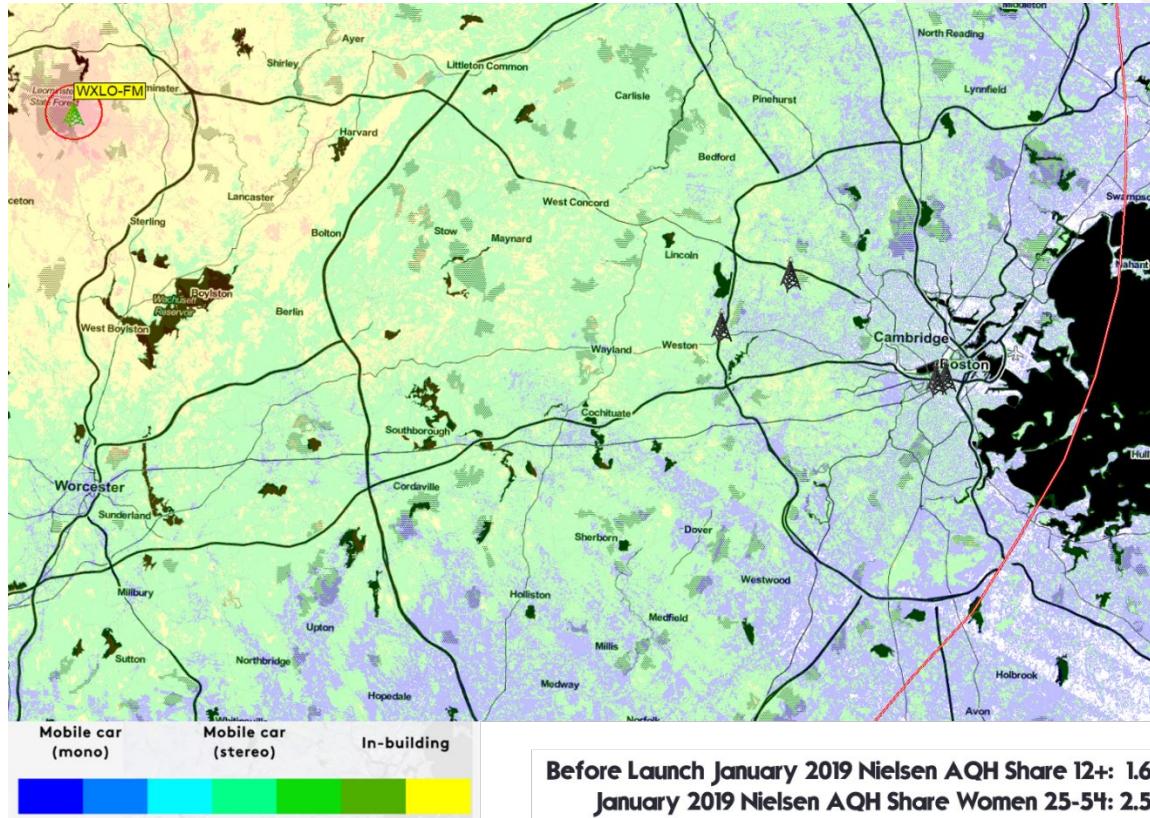
BEFORE**AFTER (1M POPs ADDED)**

NIELSEN PPM AND RATINGS

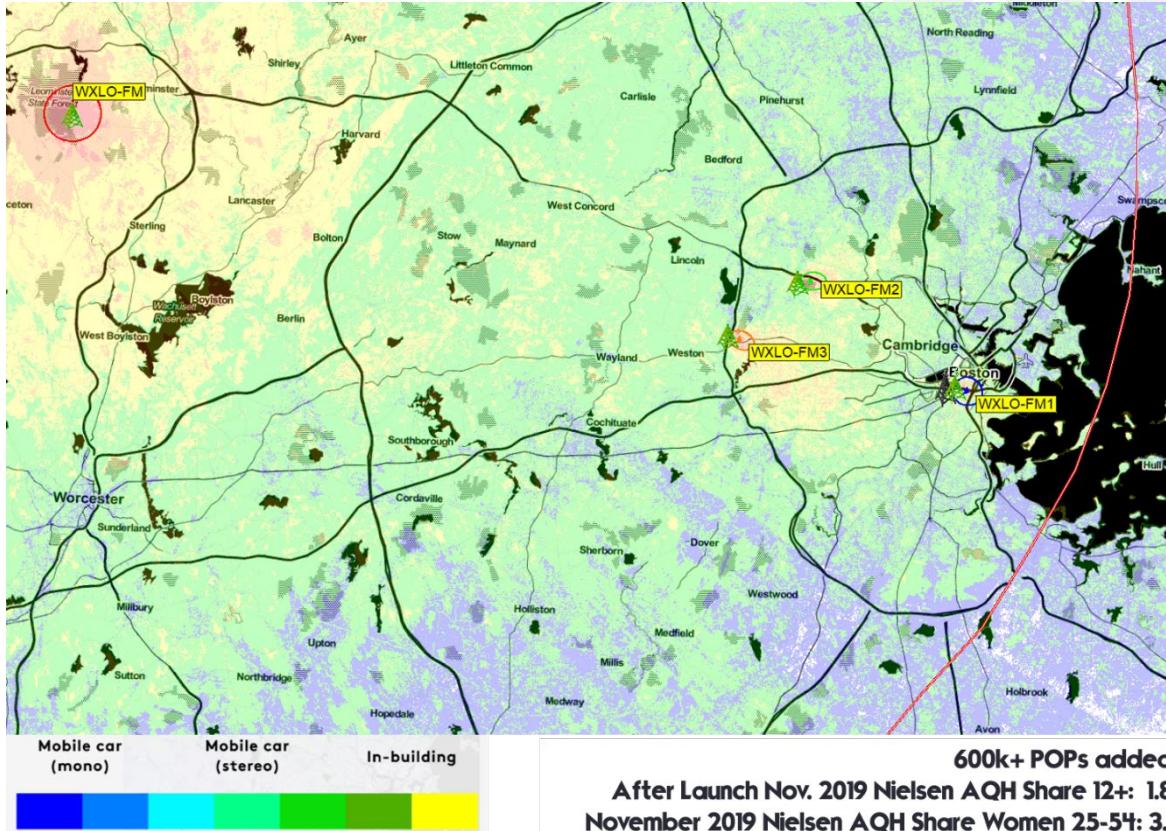
- RF Signal level is typically the most important component of audio quality
- If there isn't enough signal then watermarks can't be decoded, and there are no ratings!
- We process the audio signal thru a TVC-15 Watermark Analyzer for PPM decoding improvements



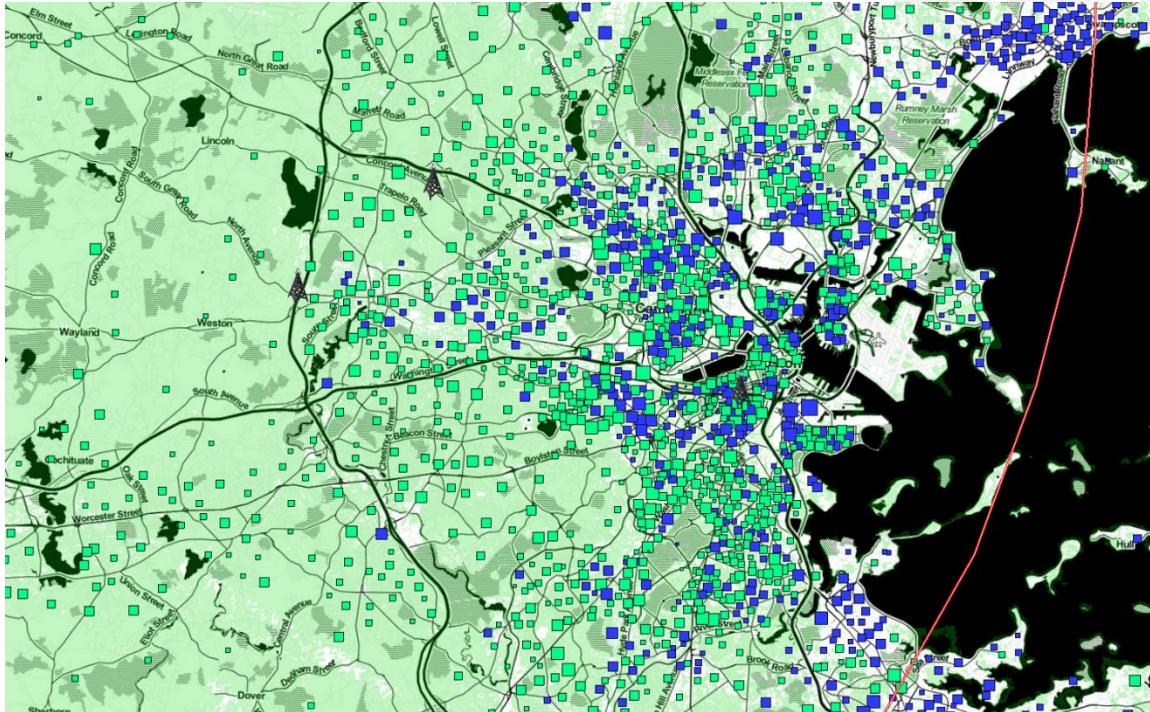
EXAMPLE DEPLOYMENT- WXLO BEFORE



EXAMPLE DEPLOYMENT- WXLO AFTER



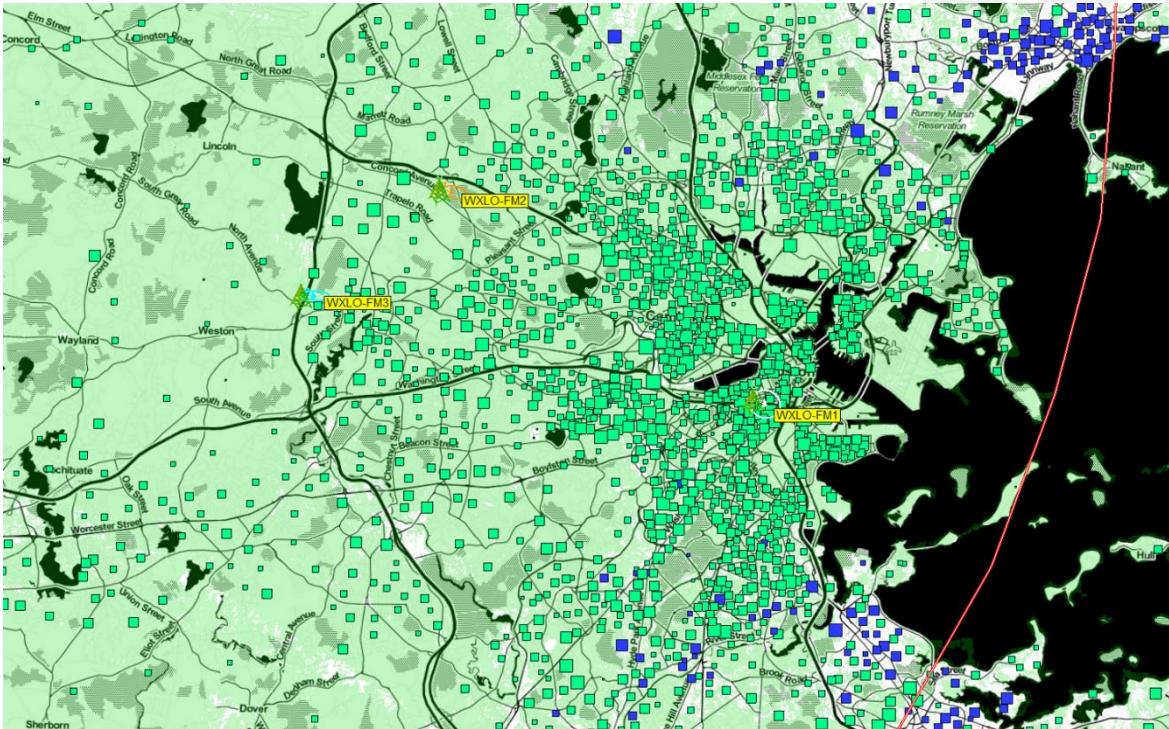
EXAMPLE DEPLOYMENT- WXLO BEFORE



Block Group < Mobile car stereo

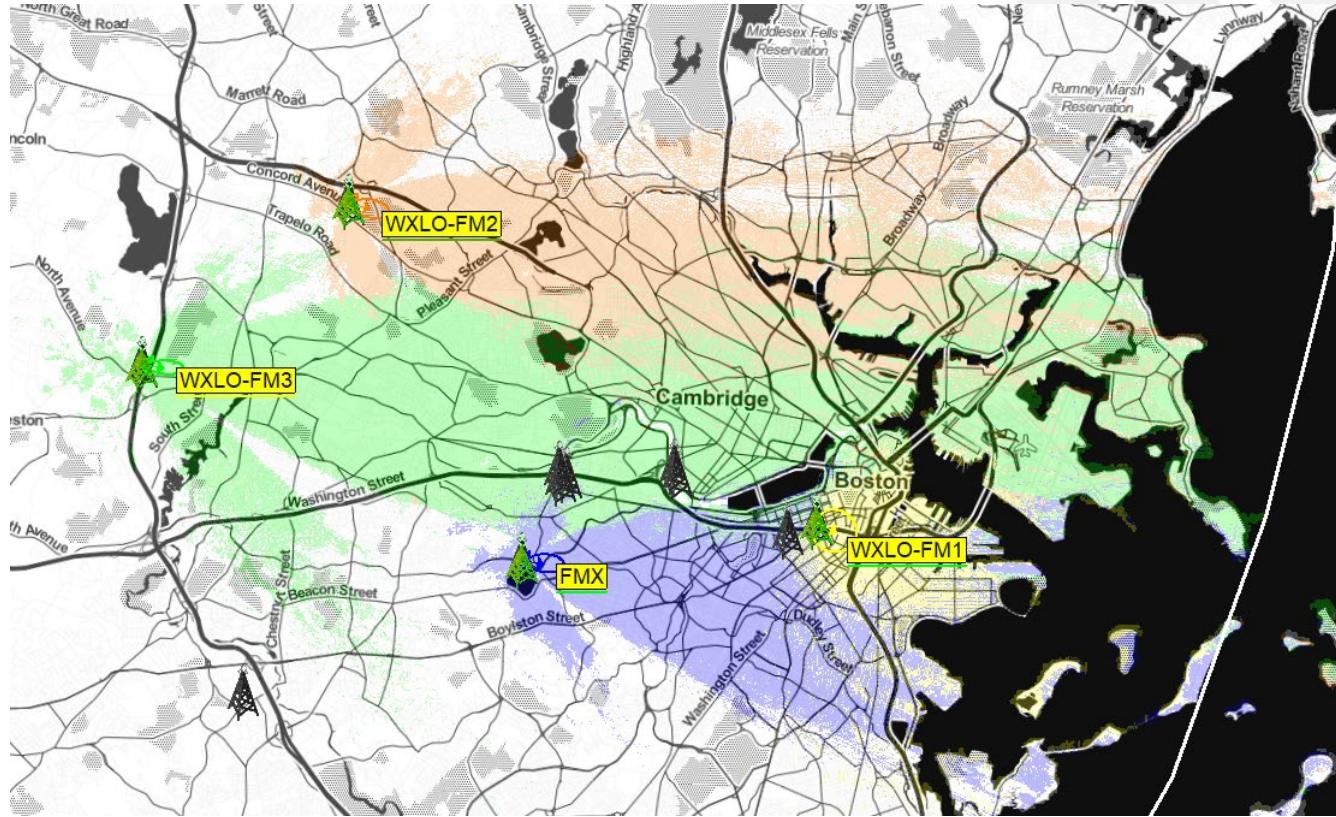
Block Group \geq Mobile car stereo

2019 Census Block Group Coverage, Women 25-54



Block Group < Mobile car stereo
Block Group \geq Mobile car stereo

2019 Census Block Group Coverage, Women 25-54
MaxxCasting 24% Pop increase
Jan to Nov 2019 Nielsen Weekly Cume Increase 52%

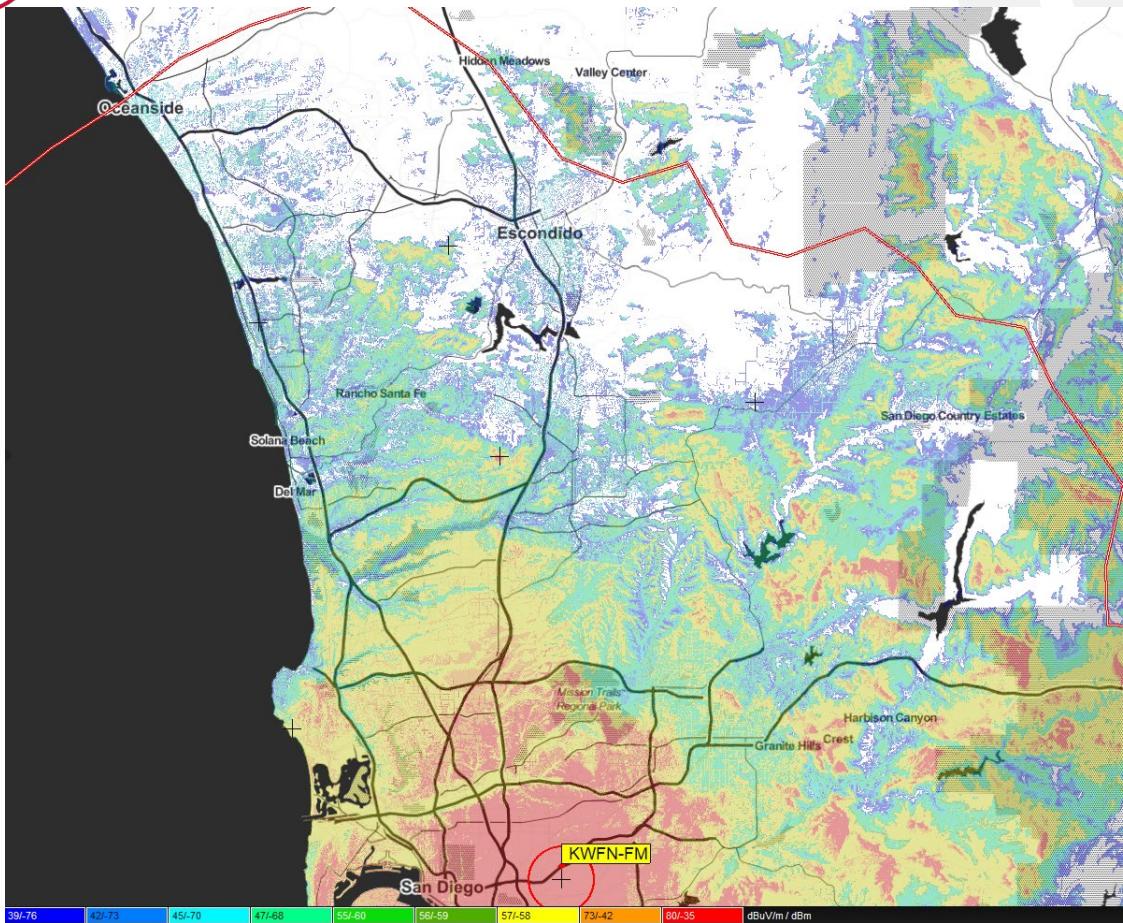


CASE STUDY – KWFN SAN DIEGO, CA

- Entercom KWFN-FM - 50 kW Class B station in San Diego CA
 - Main site centrally located in the market
 - Weaker signal in northern portion of coverage area
 - Objective to increase coverage in analog AND HD Radio
 - Intraplex IPConnect allowed both FM MPX and E2X to be reliably transported and synchronized through the entire transport network
 - Early results are positive – month over month share increase of 1.8 to 2.5%

“The San Diego market is very terrain-intensive, and signal penetration is limited due to the density of hills,” said JR Rogers, Market Technical Operations Director, San Diego for Entercom. “The MaxxCasting nodes are strategically placed into weak coverage areas to fill KWFN’s contour to its best possible capacity. I can travel Interstate 15 and receive a continuous signal. There is no question that commuter listening has improved, as the holes in the signal coverage have been greatly diminished.”

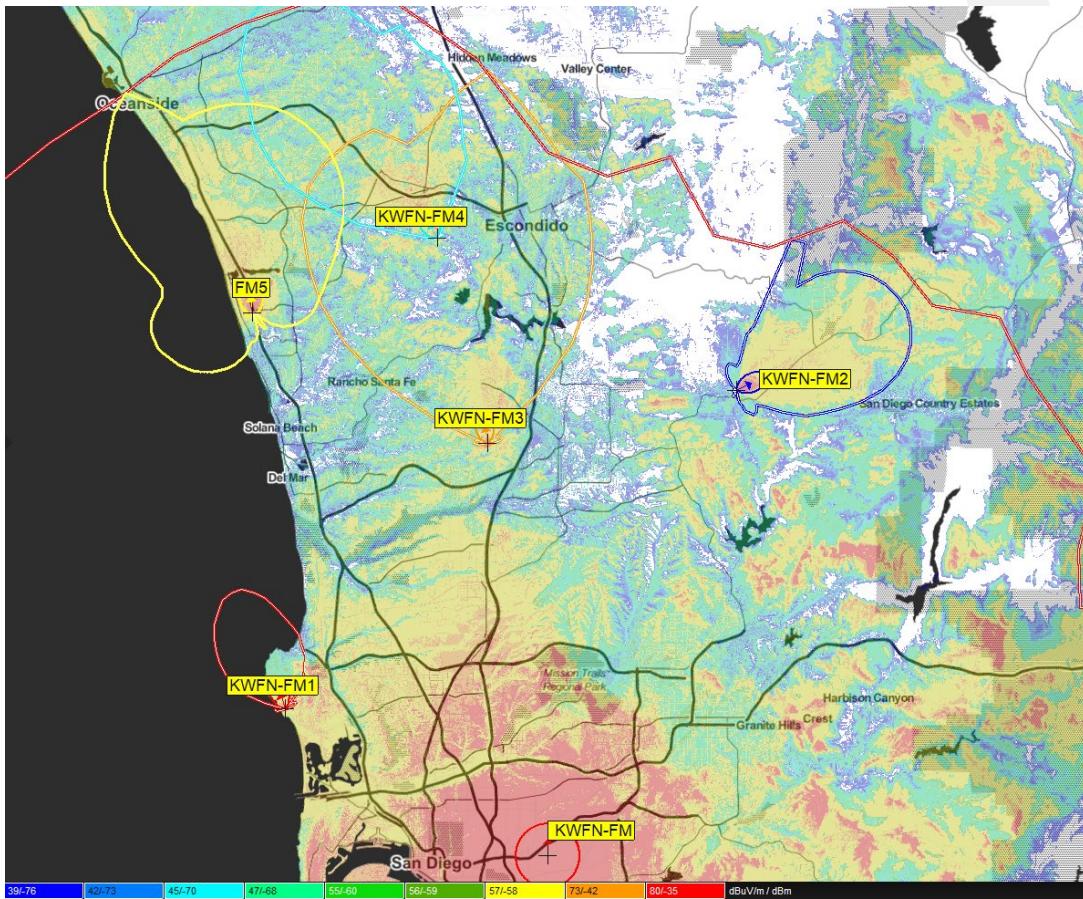
KWFN, SAN DIEGO CA - BEFORE



**KWFN RADIO
COVERGE
05.06.2019**



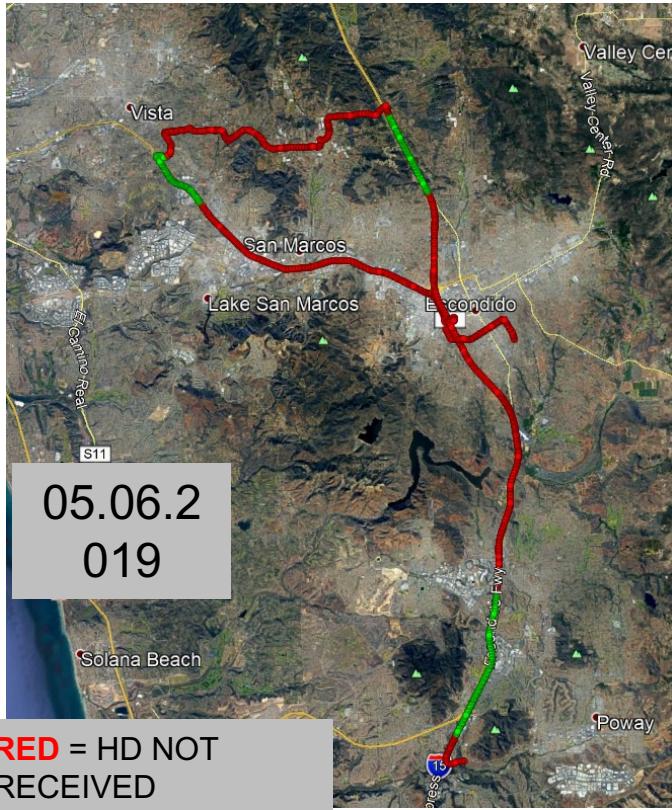
KWFN, SAN DIEGO CA - AFTER



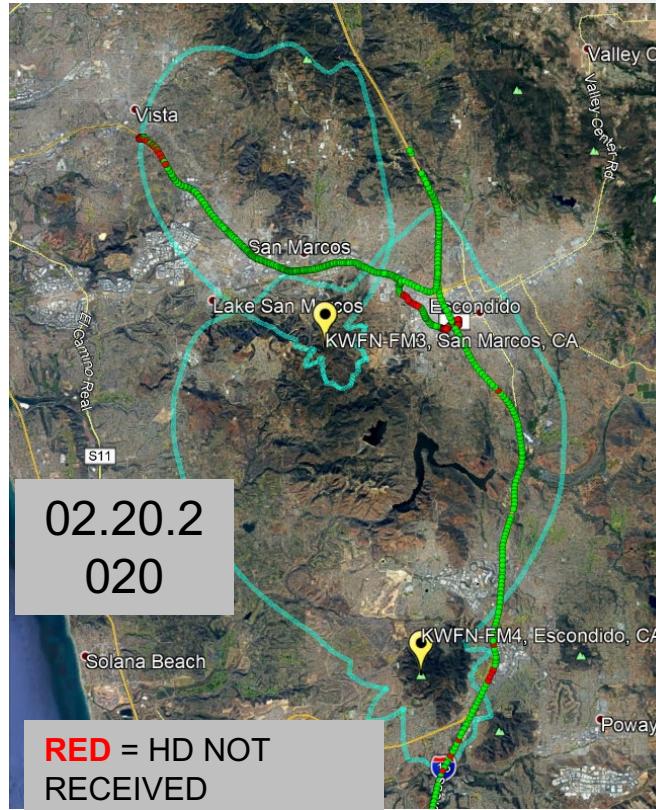
**KWFN RADIO
COVERGE
02.20.2020**



KWFN, SAN DIEGO CA – HD RADIO COMPARISON



RED = HD NOT RECEIVED
GREEN = HD RECEIVED



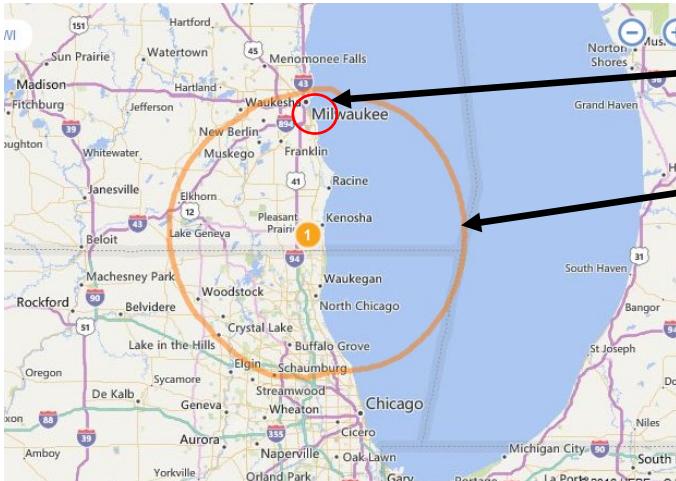
RED = HD NOT RECEIVED
GREEN = HD RECEIVED

ANOTHER FORM OF SFN USE – ZONECASTING™

- 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.
- GBS & GatesAir performed 3 field tests under FCC special authorizations
 - In a variety of environments Salt Lake City (KDUT in 2010), Sebring, Florida (WWOJ in 2011), Milwaukee in (WIIL in 2017)
 - Milwaukee design deployed and commercially operational in France 2017
- Technically patented and proven architecture
- FM design parameters verified by NPR Labs & Towson University
- A very simple change in current FCC rules is needed [74.1231 (i)]
 - GBS has Petition for Rulemaking RM-11659 – open for comments

MAXXCASTING VS ZONECASTING

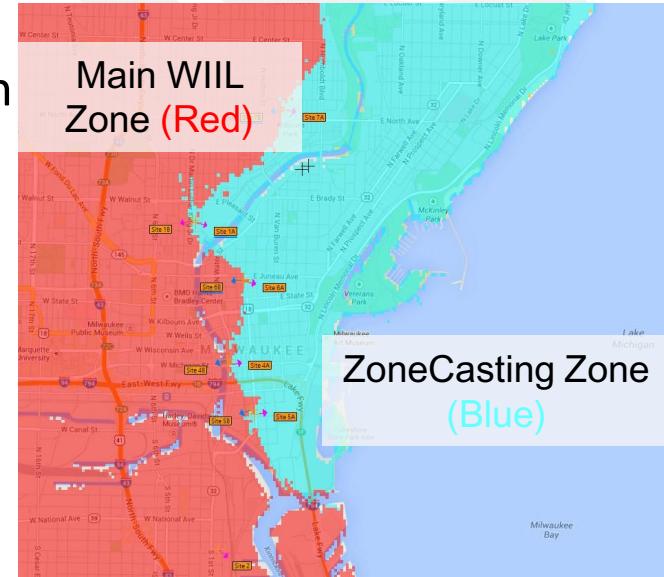
- MaxxCasting is 100% SIMULCAST of the main station.
 - ZoneCasting sets up one or more INDEPENDENT zones with SEPARATE programming from the main
 - In Milwaukee, BOTH are used in a hybrid system.
 - Both technologies are Patented.



Area of interest

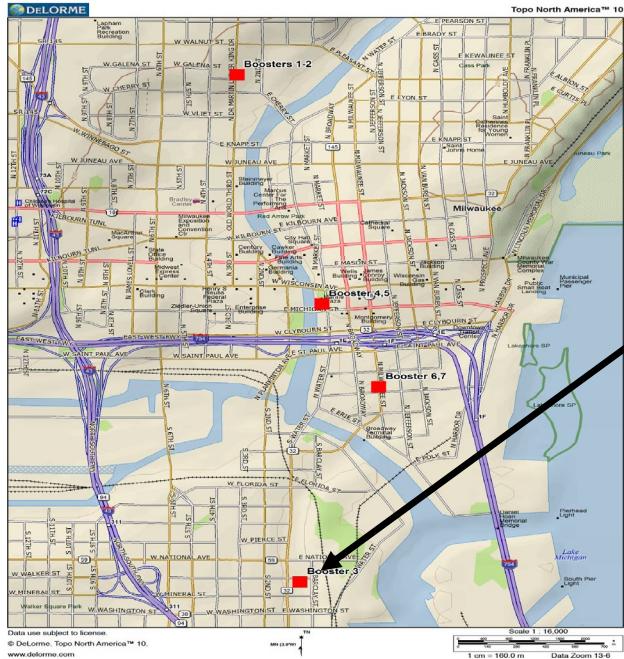
-WIIL 54 dBu Contour

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



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

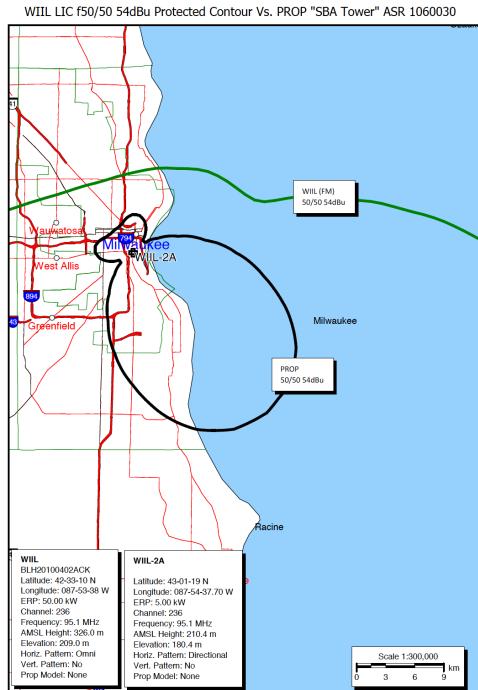
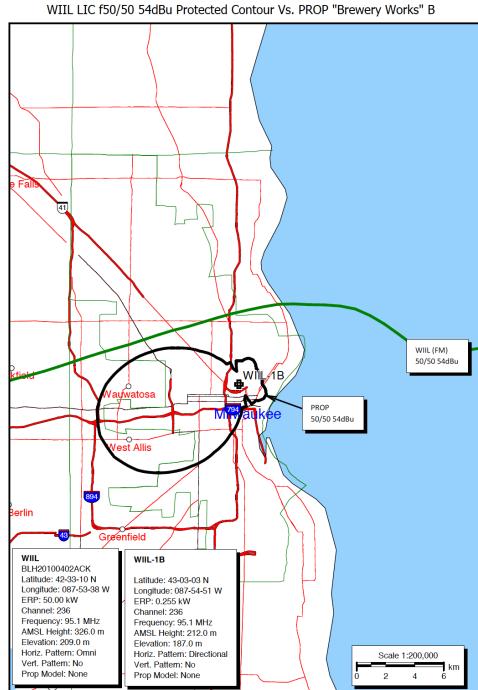
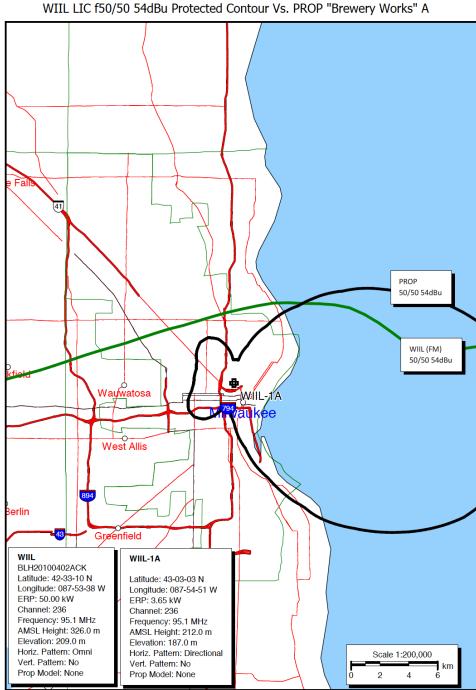
FCC Rules permit boosters to operate up to 20% of main FM class power

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

GATESAIR THE NODES

VIRTUAL events

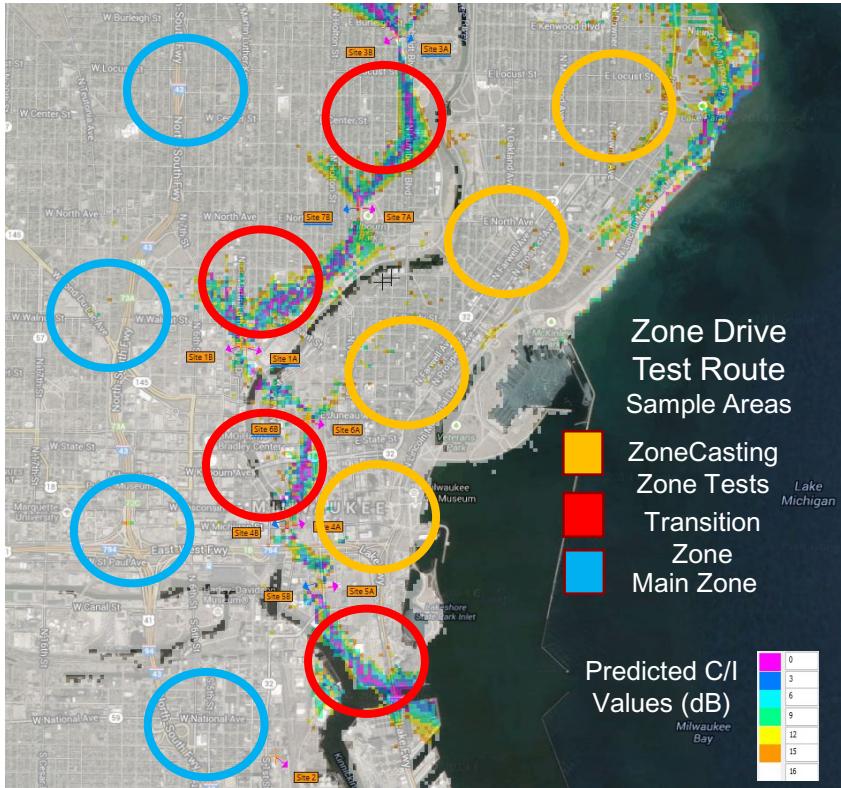


MILWAUKEE SITE PICTURES



GATESAIR ZONE DRIVE TEST

VIRTUAL events



- 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.

- Most asked technical question: How to avoid interference?
- IF a station is in ZoneCasting Geo-Targeted mode (predict avg 2-3 min per hour) AND
- IF a receiver is on that frequency AND
- IF that receiver passes thru the border between zones
- THEN
 - The audio changes from one sound source to another (quickly- in a few seconds)
 - Geo uses advanced cellular planning tools with very high resolution cartography (terrain, buildings, etc.) and automobile traffic information to minimize transition areas so listeners wont notice
- **Statistically under 1% of station listeners will hear transition from main to zoned area**
- Mobile TV using Next Gen Zoned SFN will have similar transitions

THE 107.7 IN FRANCE

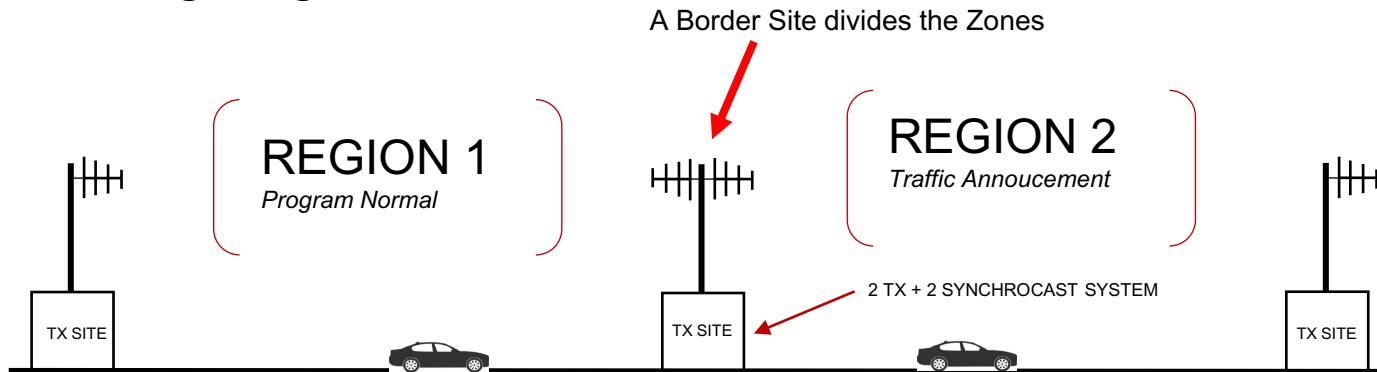
- 107.7 is the only single frequency assigned for the same program category. Reserved in the past to the Army, the government decided, in 1991, to release it to allow the radios highway of to develop.
- Each radio has its own identity, its own organization of traffic information and how to treat it. In addition, each gives more or less importance to the news of the road and drivers, the promotion of the territories they cross. Their musical program is not the same either.



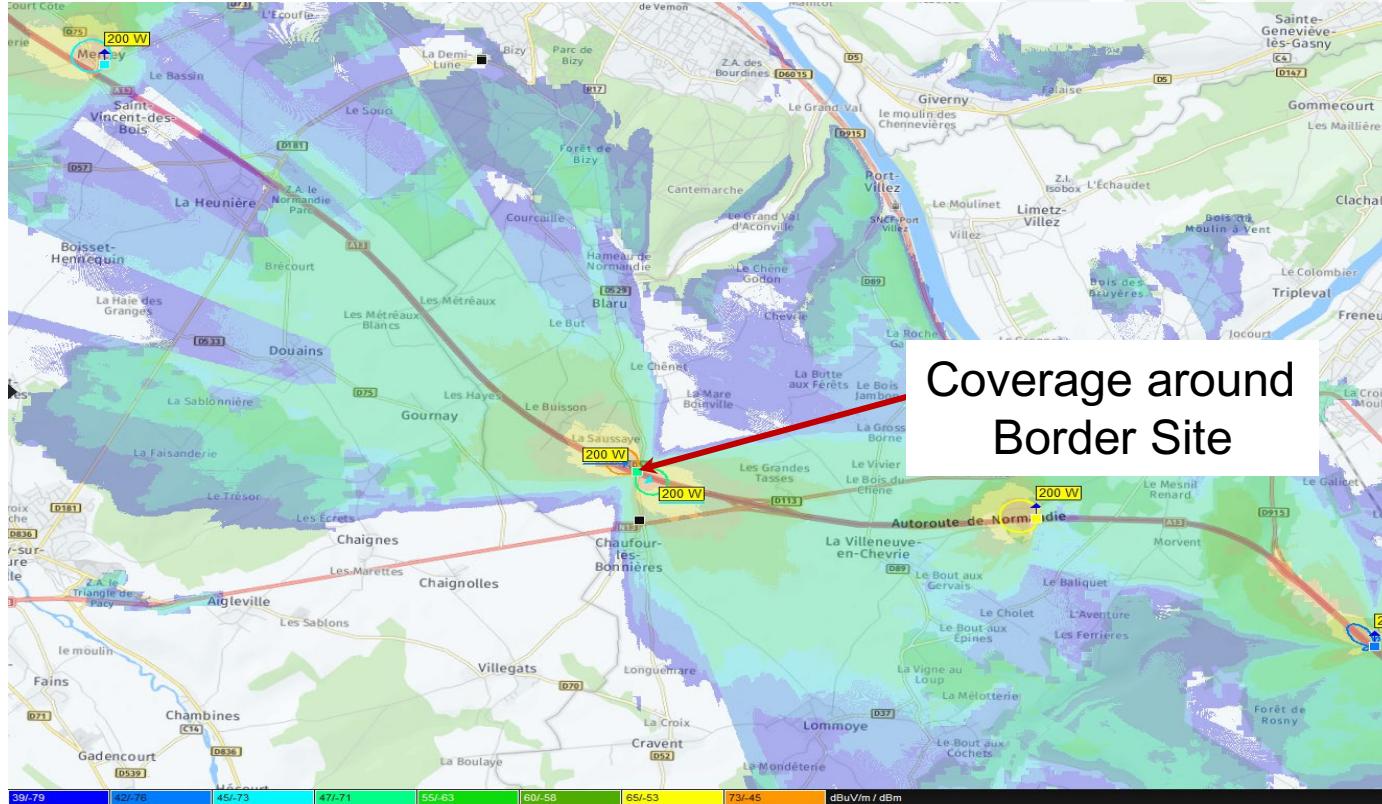
GATESAIR THE 107.7 IN FRANCE

VIRTUAL events

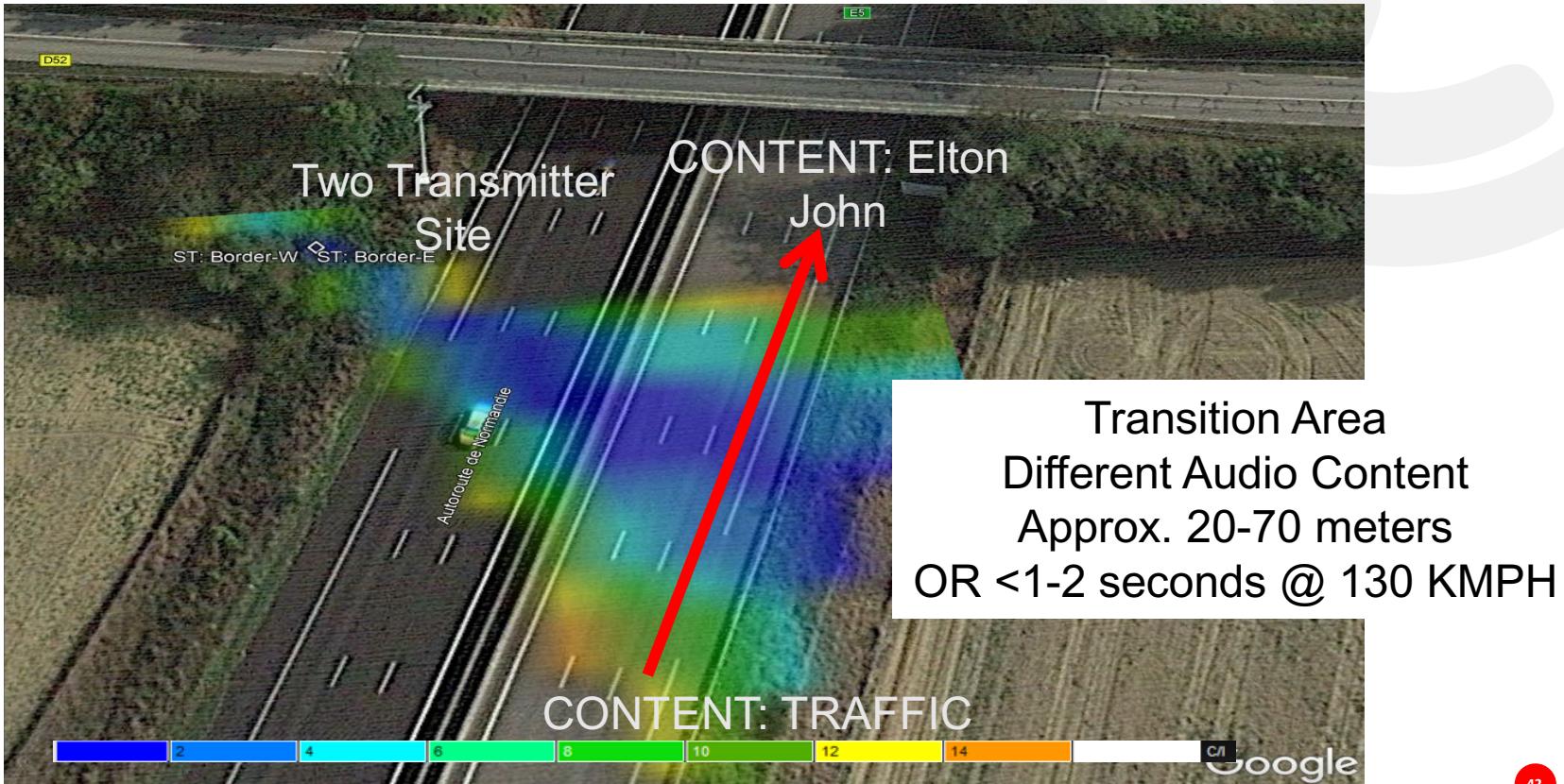
- The 107.7 MHz frequency is dedicated for traffic and operated by different highway operators. When not broadcasting traffic it has music, news, and other programming that vary by region.
- Over 1,100 transmitters (one every 8-10 kilometers on average) are set up to broadcast the radio on a single frequency
- Have started to Geo-Target Traffic audio updates using the Milwaukee ZoneCasting design in 2017**



EXAMPLE: A13 AUTOROUTE PARIS TO CAEN



EXAMPLE: A13 AUTOROUTE PARIS TO CAEN





GATESAIR CONCLUSION

VIRTUAL events

- 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 SFN networks have long been regulatory options, the reality of a useful deployment escaped many who tried and resulted in years of belief that "FM SFN just doesn't work."
- Digital radio testing shows similar results as analog FM
- Today's advances in technology and system design capabilities prove FM SFN not only works, and works well, it 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.



THANK YOU

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