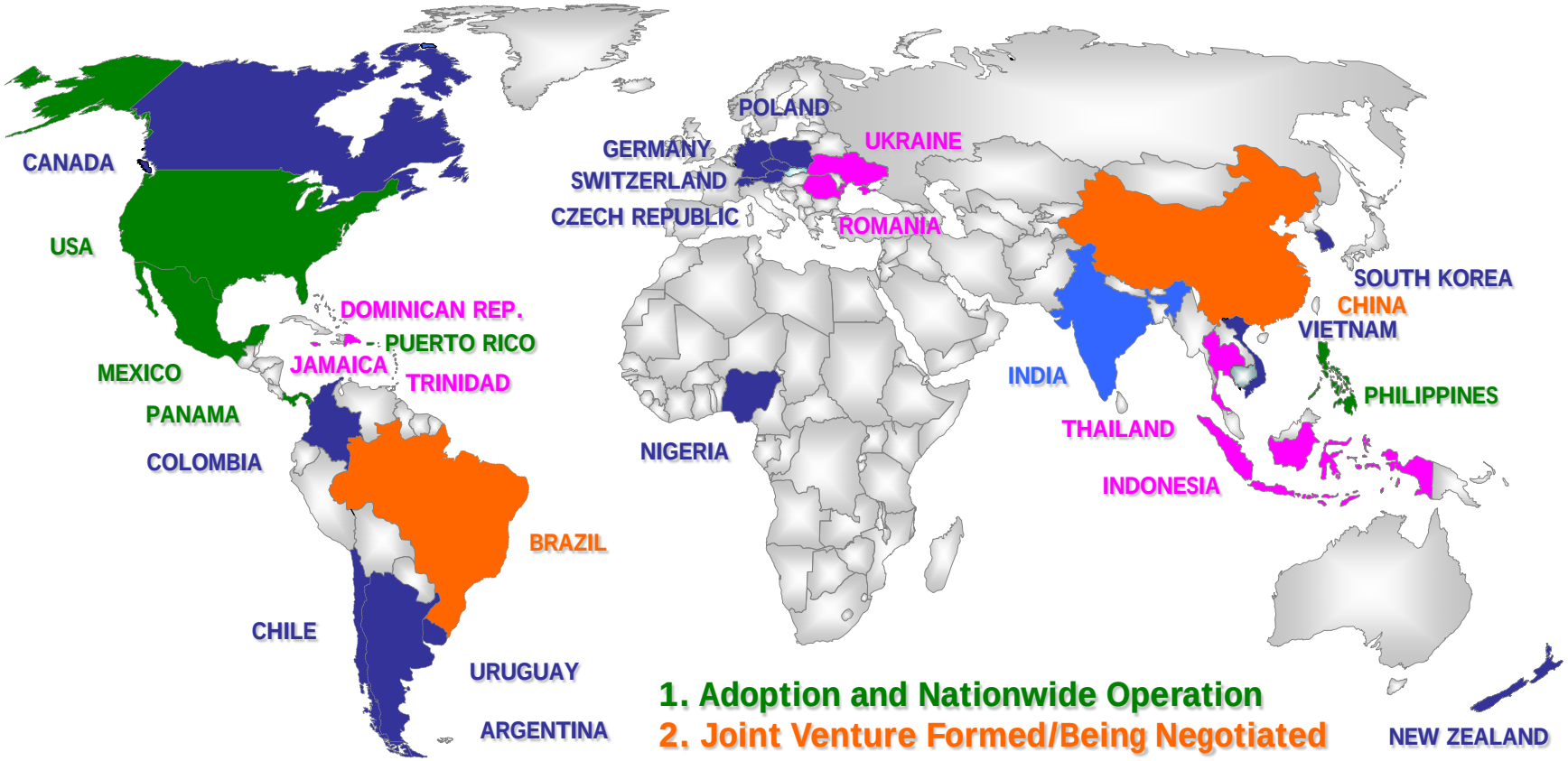
HD Radio™ Technology

FM & AM DIGITAL RADIO UPDATES
October 2013

Andy Laird
Journal Broadcast Group

International Penetration

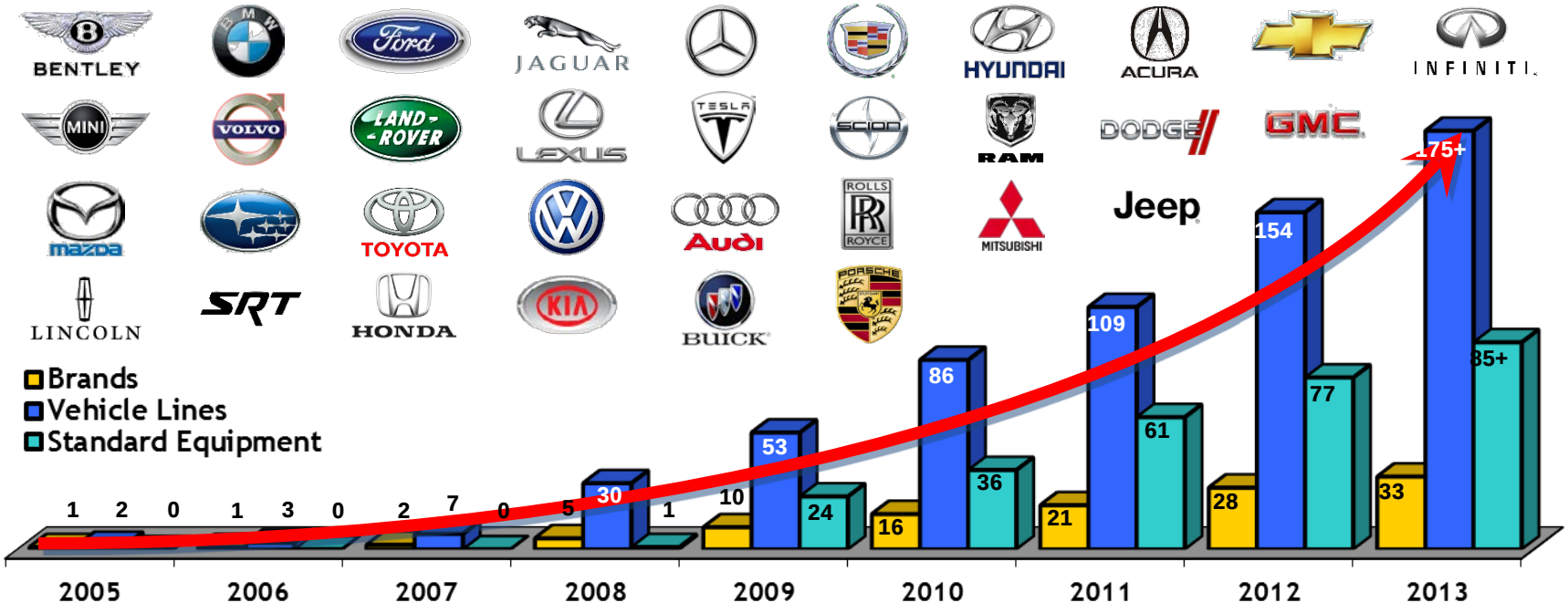
- **International rollout status**



Wide Availability on Automotive Platforms

- These 33 auto brands currently offer factory-installed HD Radio Technology

Announced - Available Now Or During The 2013 Calendar Year



As of September 2013

HD Radio®

HD Radio Automotive: The Big Picture

- **These 33 auto brands currently offer factory-installed HD Radio Technology**

HD Radio Technology Standard Feature On All Vehicles

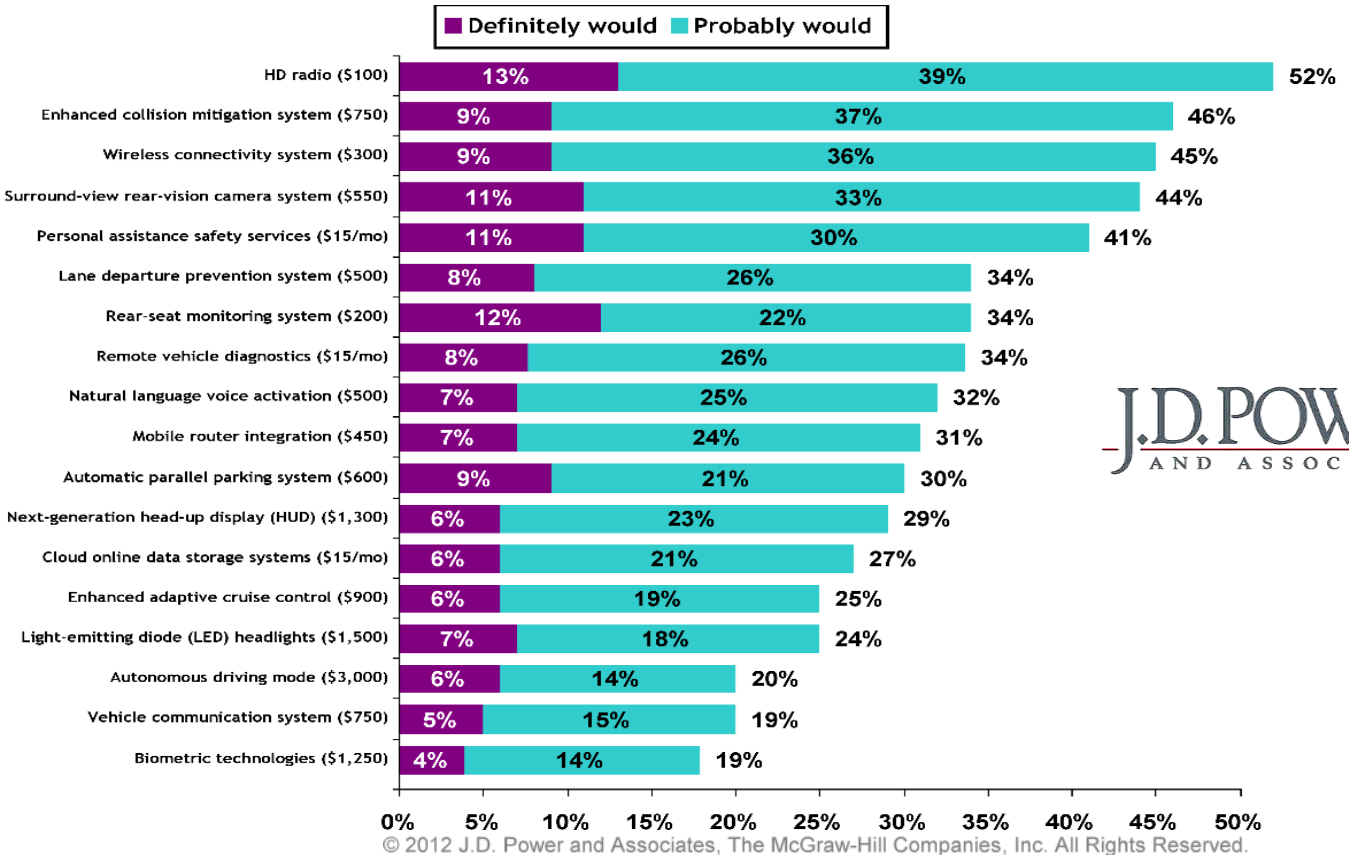
HD Radio Technology Standard Feature On Some Vehicles

HD Radio Technology Available As Part Of Option Package

HD Radio®

HD Radio Automotive: The Big Picture

- **Consumers extremely interested in adding HD Radio Technology**



J.D. POWER AND ASSOCIATES®

HD Radio®

HD Radio Technology is Incorporated by Virtually all Top CE Manufacturers

Most Major Brands – 100 SKUs – All CE Categories

Auto Aftermarket

ALPINE KENWOOD Pioneer SONY JVC

Home & iPod Docking Systems

marantz Integra YAMAHA ONKYO DENON

Portable & Mobile

INSIGNIA GARMIN AUDIOVOX

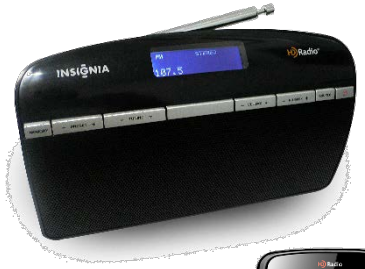
HD Radio®

Note: Partial Listings depicted here.

Consumer Receiver Availability

- Many HD Radio consumer receivers are available at various price points

$49 | **$99** | **$149** | **$249+**



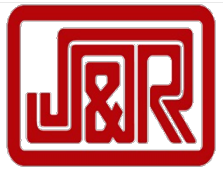
HD Radio®

Consumer Receiver Availability

- A wide variety of models are available from almost 60 different manufacturers

Consumer Receiver Availability

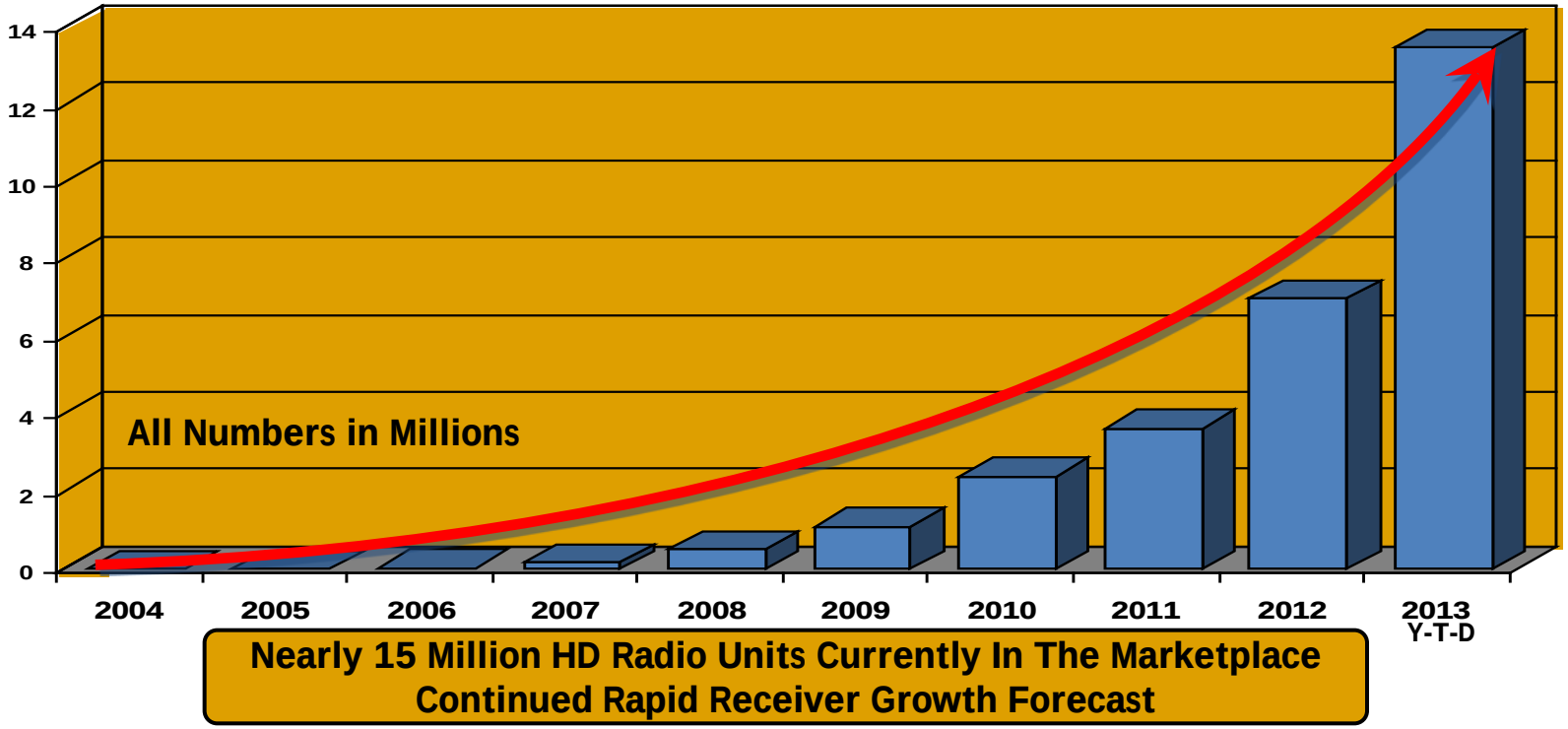
- There are over 10,000 traditional and on-line retailers offering HD Radio receivers



HD Radio

Consumer Receiver Availability

- **Receiver sales growth is also reaching critical mass**



As of September 2013

Consumer Receiver Availability

- **Auto aftermarket receivers with advanced HD features:**

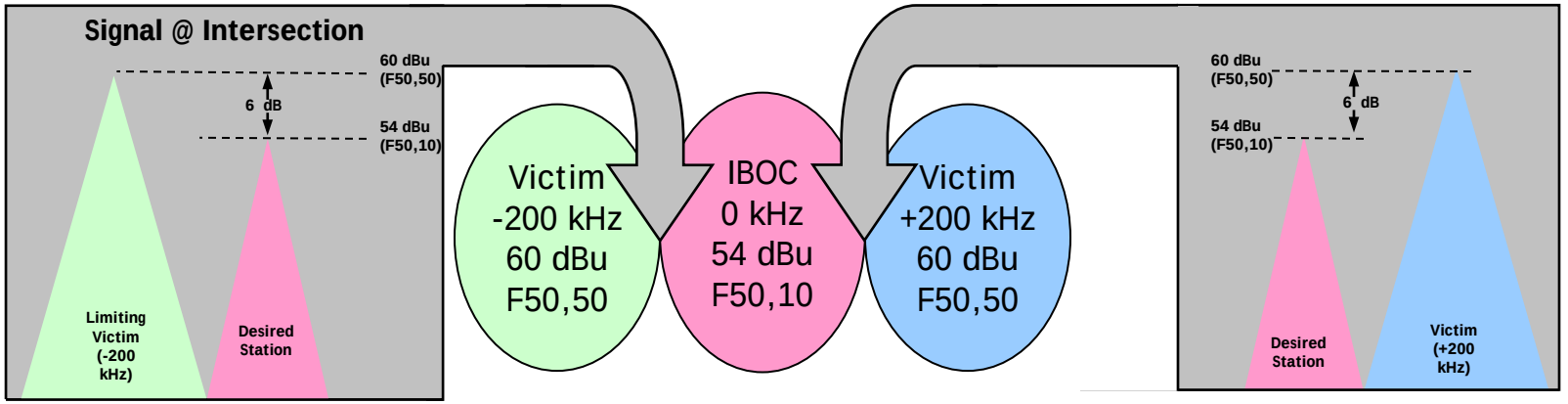
HD Radio®

Field Test Results
WKLB, Boston
102.5 MHz

Paul Shulins, Greater Media, Boston

HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

- Traditional 1st Adjacent Analog Spacing Requirements
  - Interfering Station's F50,10 Contour Must Be 6 dB Below Victim's Protected F50,50
  - Protected F50,50 Contour is 60 dBu For All Classes Except B
  - Class B Protected F50,50 Contours are 54 dBu
  - Class B1 Protected F50,50 Contours are 57 dBu
- IBOC Spacing Follows Analog



HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

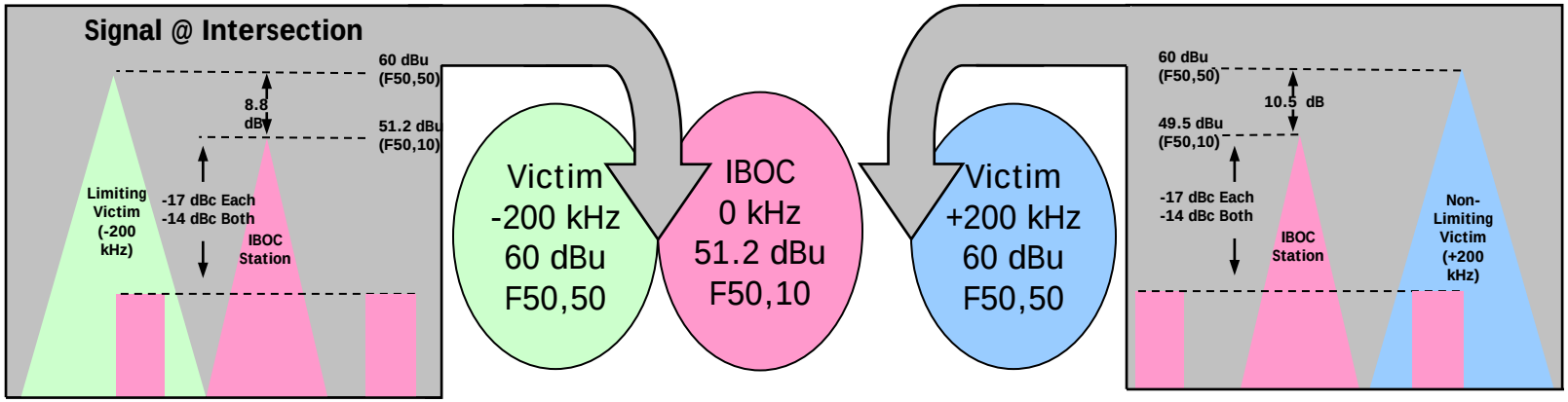
- Across the board Power Increase of 6dB (to -14 dBc) Authorized January 29, 2010
  - MM Docket 99-325
- IBOC Power Levels Above -14 dBc Possible
  - Dependent On IBOC Station's F50,10 Signal @ Victim's 60 dBu F50,50
    - ≥ 51.2 dBu* → -14 dBc
    - 50.7 to 51.2 dBu → -13 dBc
    - 50.3 to 50.7 dBu → -12 dBc
    - 49.6 to 50.3 dBu → -11 dBc
    - 49.5 to 49.6 dBu → -10 dBc

* Approximately 57.2 dBu @ Victim's 54 dBu F50,50 Contour

HD Radio Field Performance with

Unequal Digital Sideband Carrier Levels

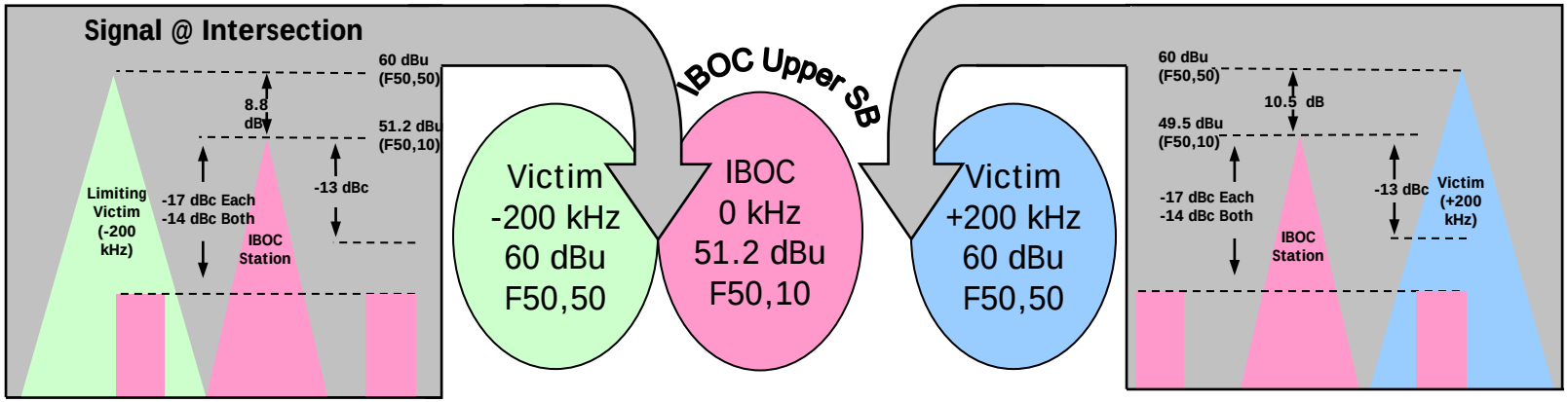
- Maximum symmetric power increase is limited by the sideband causing worst-case 1st adjacent interference.
- The other, potentially interference “clear” sideband’s power must be identical.



HD Radio Field Performance with

Unequal Digital Sideband Carrier Levels

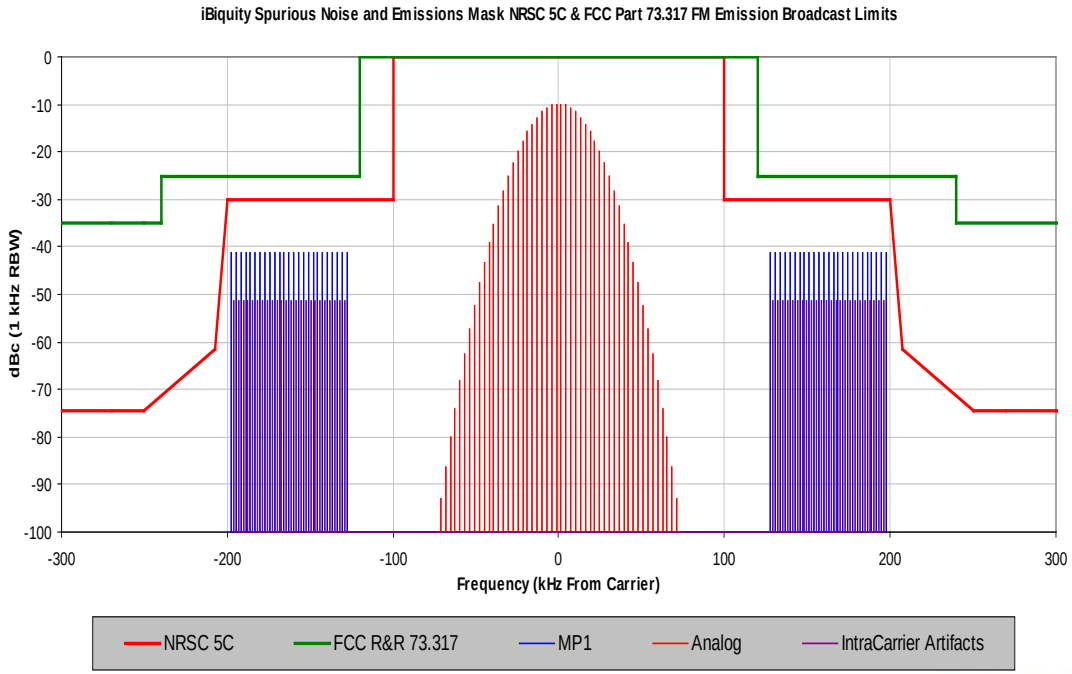
- Asymmetric IBOC Sideband Transmission
  - Allows Independent Adjustment of Each Sideband
    - Upper and Lower Sideband May be Increased to Their Individual Limits
    - Potential 2.45 dB Total Power Increase for Asymmetry of 4 dB (-17 dBc/-13 dBc)



HD Radio Field Performance with

Unequal Digital Sideband Carrier Levels

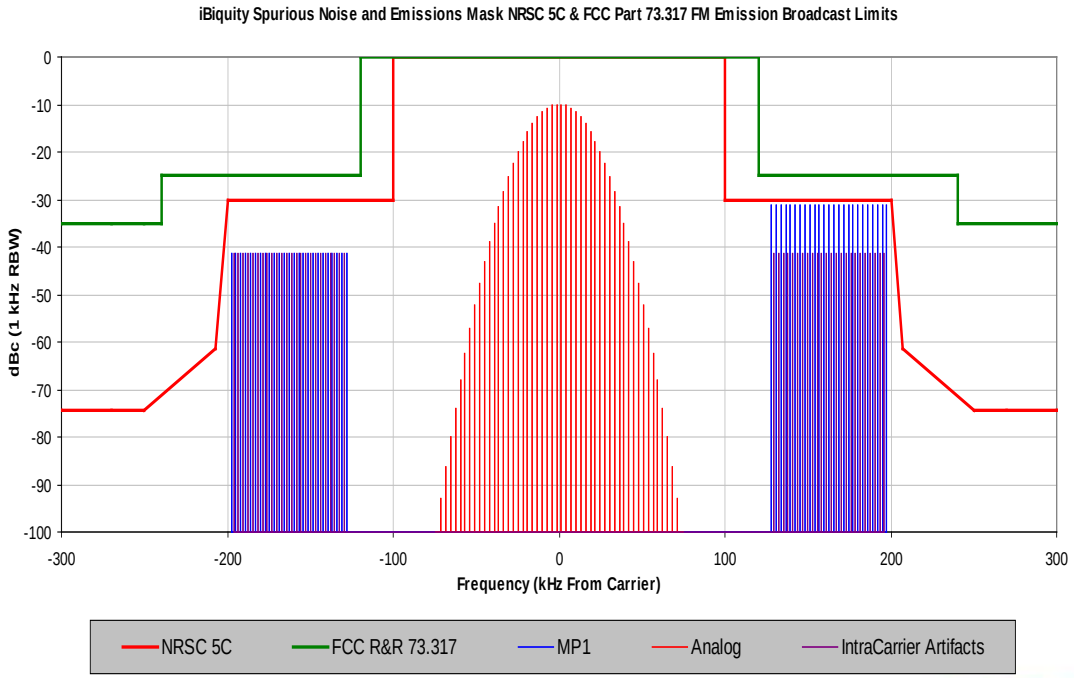
- Traditional HD Radio™ Mode MP1 Waveform @ -20 dBc
  - PAR ≈ 7 dB
  - PAR Induced Distortion Only in Active Subcarrier Bandwidth



HD Radio Field Performance with

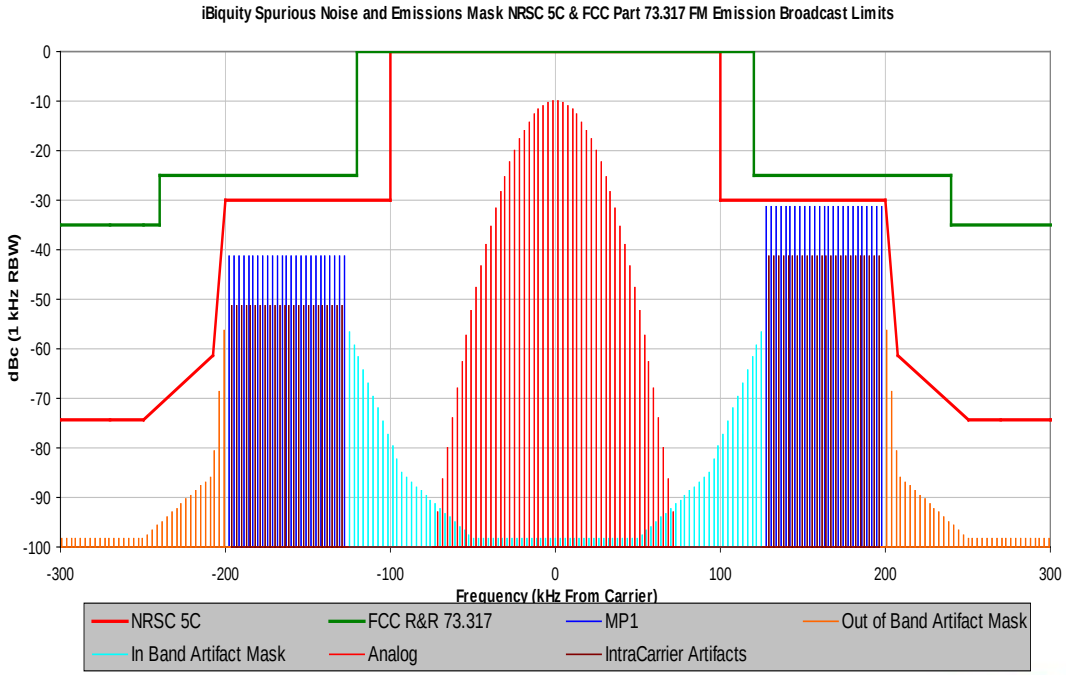
Unequal Digital Sideband Carrier Levels

- Traditional HD Radio™ Mode MP1 Waveform @ -20 dBc
  - Lack of Subcarrier Level Scaling Makes Carrier Asymmetry Impossible
  - Subcarrier Distortion Not Scaled to Carrier Level, Lower Power Carriers Compromised



HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

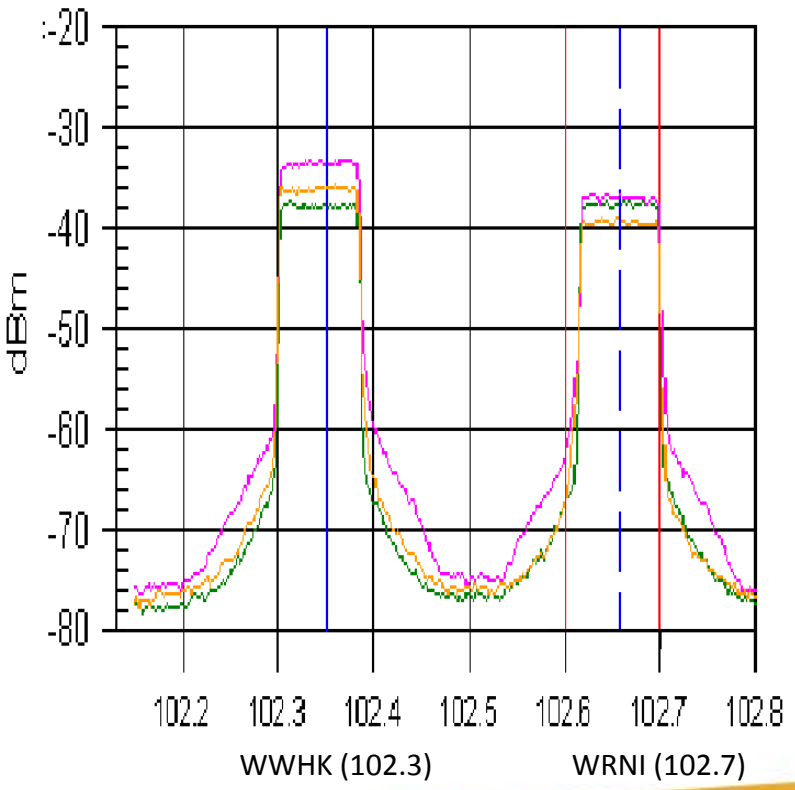
- New Peak to Average Ratio Reduction Method
  - PAR > 5 dB Possible (>2 db Better Than Old Algorithm)
  - Artifacts Allowed In Band and Out of Band (Under NRSC 5C Mask), Improving Performance
  - Subcarrier Distortion Reduced by Multiple Iterations of PAR Algorithm & Scaled to Carrier Level



HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

- WKLB 102.5 MHz, Boston Performance Testing
  - Transmission Parameters

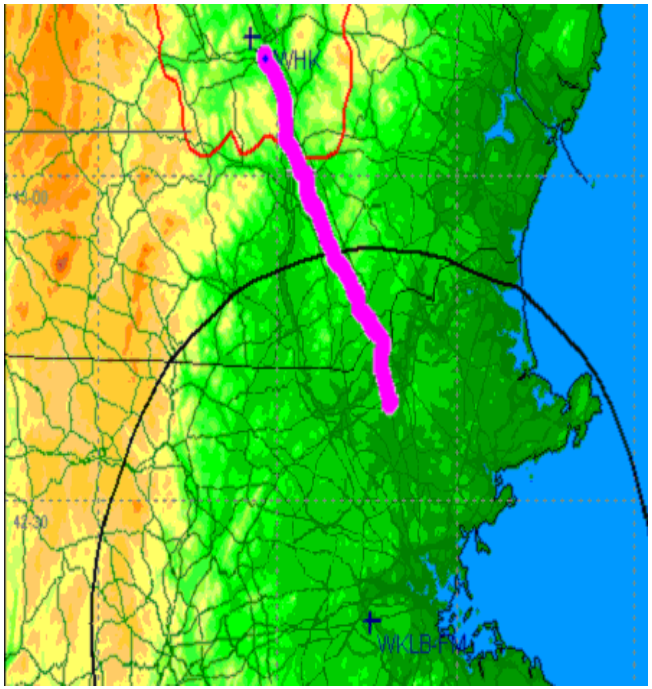
D/A Ratio (dBc) * LSB / USB	Wattmeter Total Power (watts)	Raw Channel Power (from Analyzer)		
		LSB (dBm)	USB (dBm)	LSB – USB (dB)
-17 / -17*	655	-18.21	-18.25	0.04
-13 / -17*	1136	-14.93	-18.18	3.25
-15.15 / -18.4	655	-17.49	-20.60	3.11



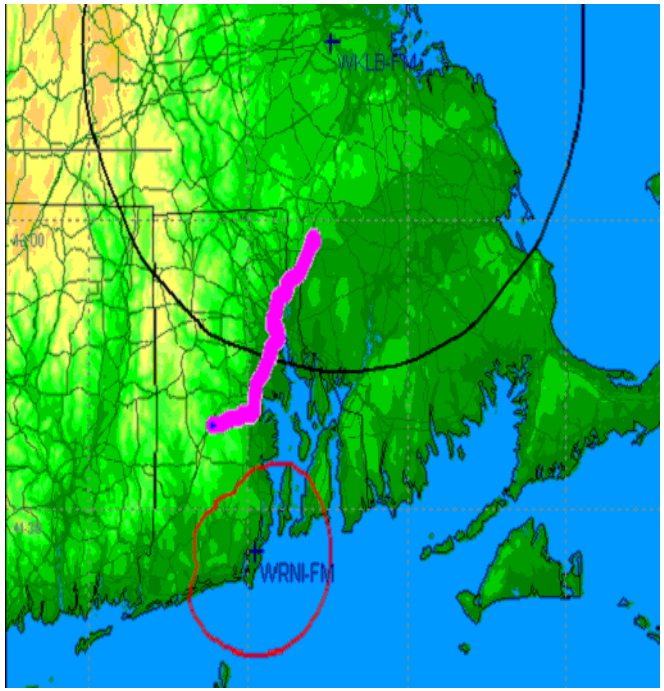
* **Note: Experimental Authorization**
Limited USB to -17 dBc Maximum

HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

- Two Test Routes



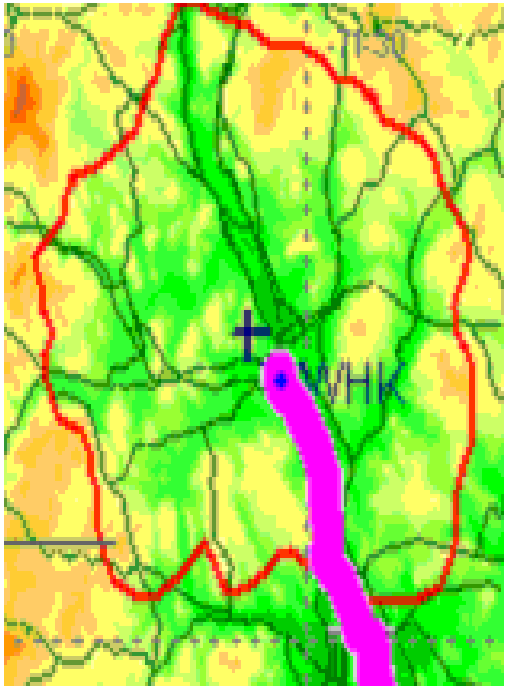
I-93 North to Manchester NH



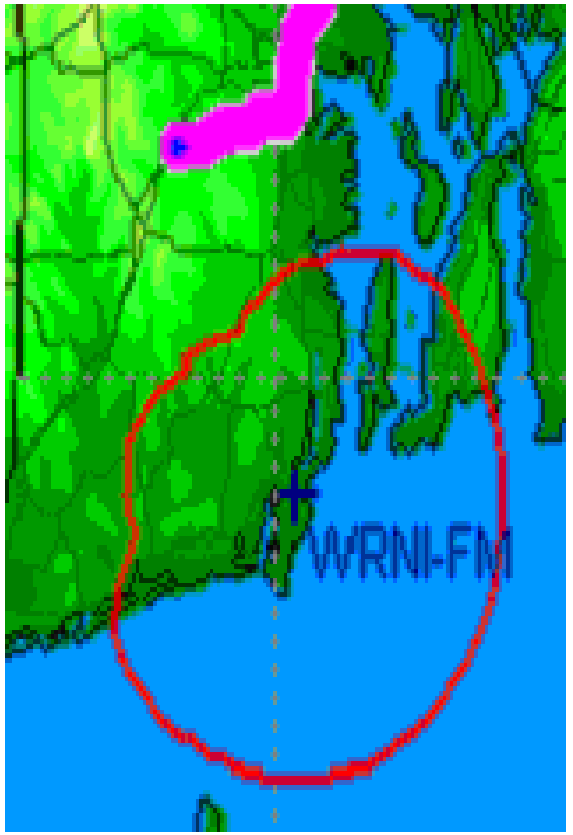
I-95 South to Warwick, RI

HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

- First Adjacent Interference

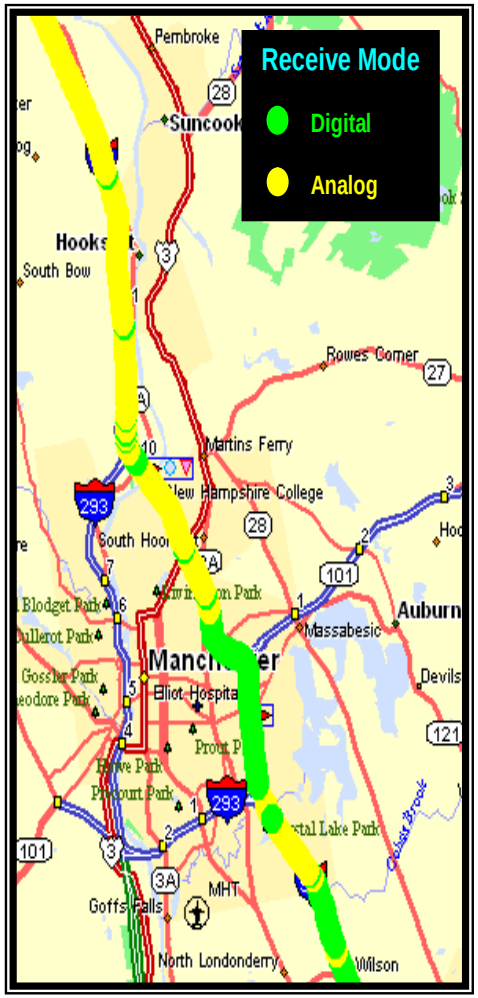


WWHK 102.3 MHz / Concord, NH

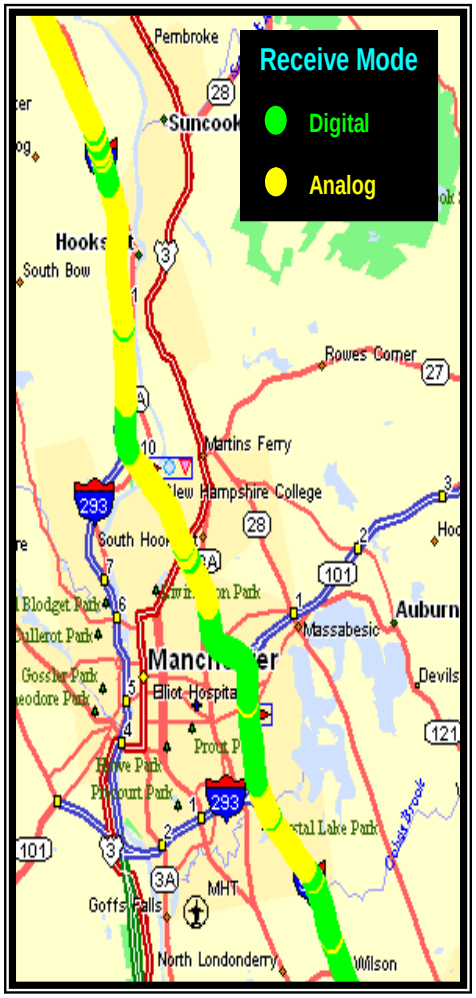


WRNI 102.7 MHz / Narragansett, RI

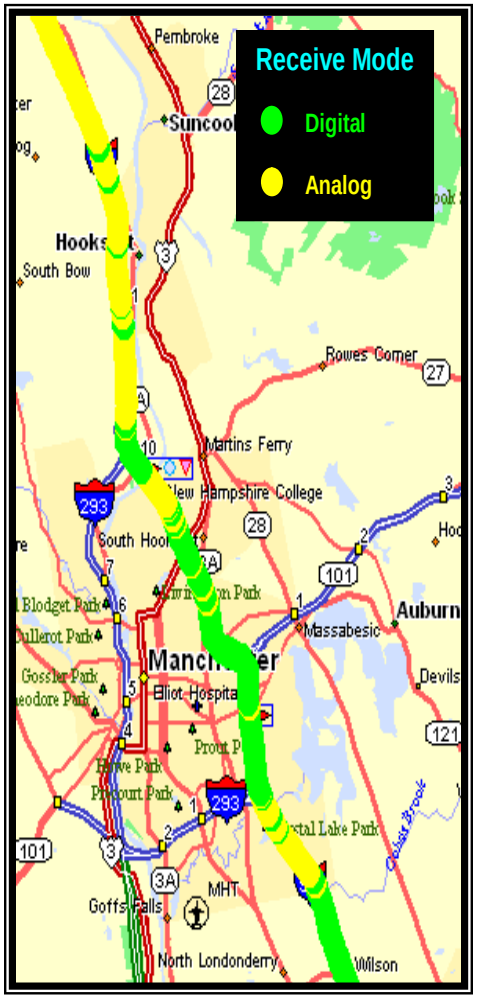
North Route (Away From Transmitter)



-17 dBc / -17 dBc (-14 dBc Total)



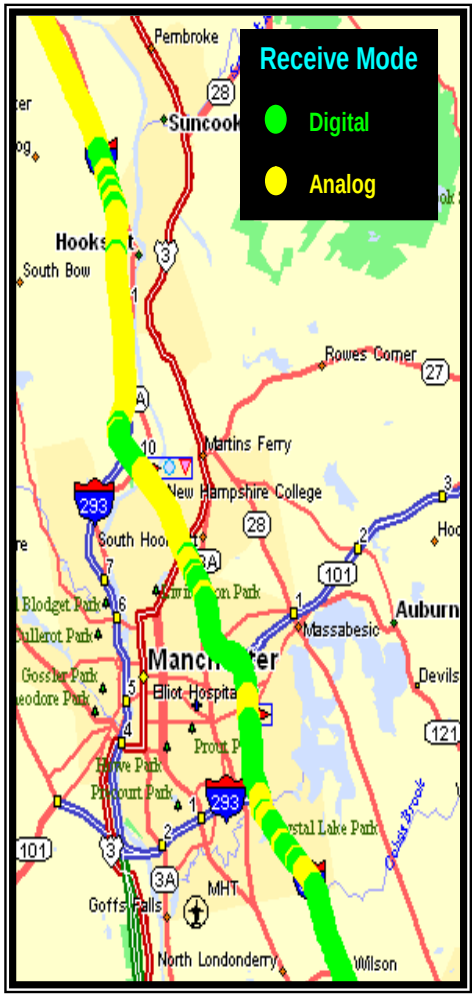
-15.65 dBc / -18.9 dBc (-14 dBc Total)



-13.75 dBc / -17 dBc (-12.1 dBc Total)

North Route (Toward Transmitter)

-17 dBc / -17 dBc (-14 dBc Total)



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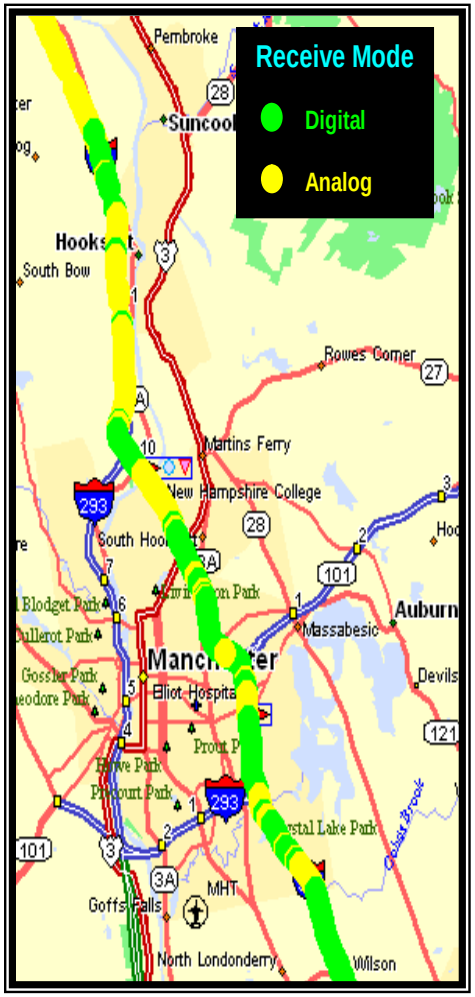
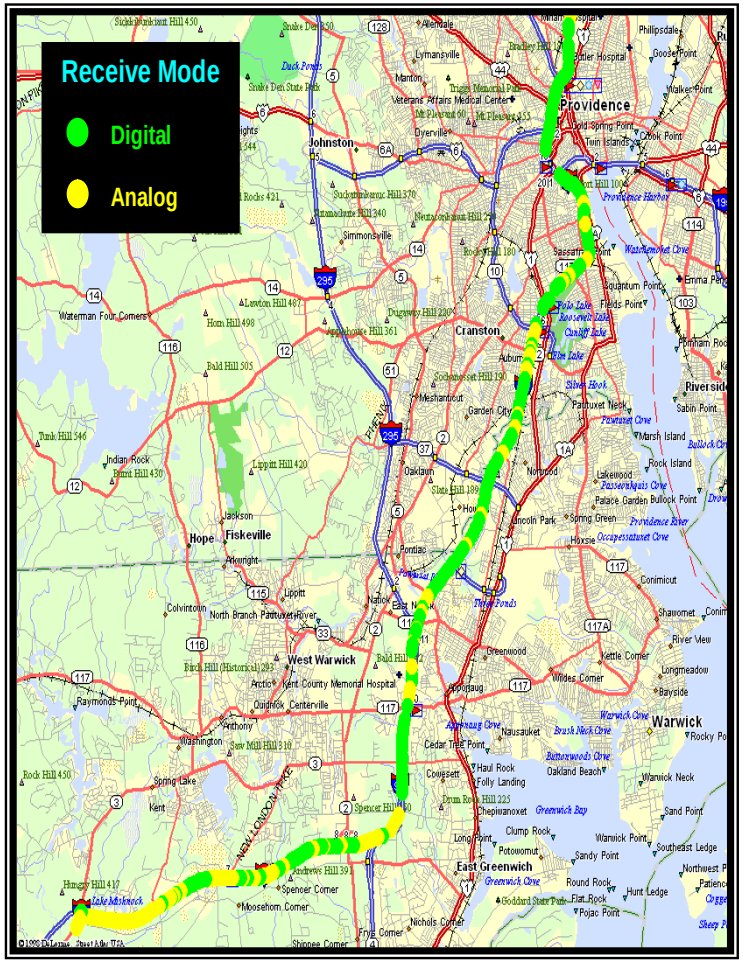
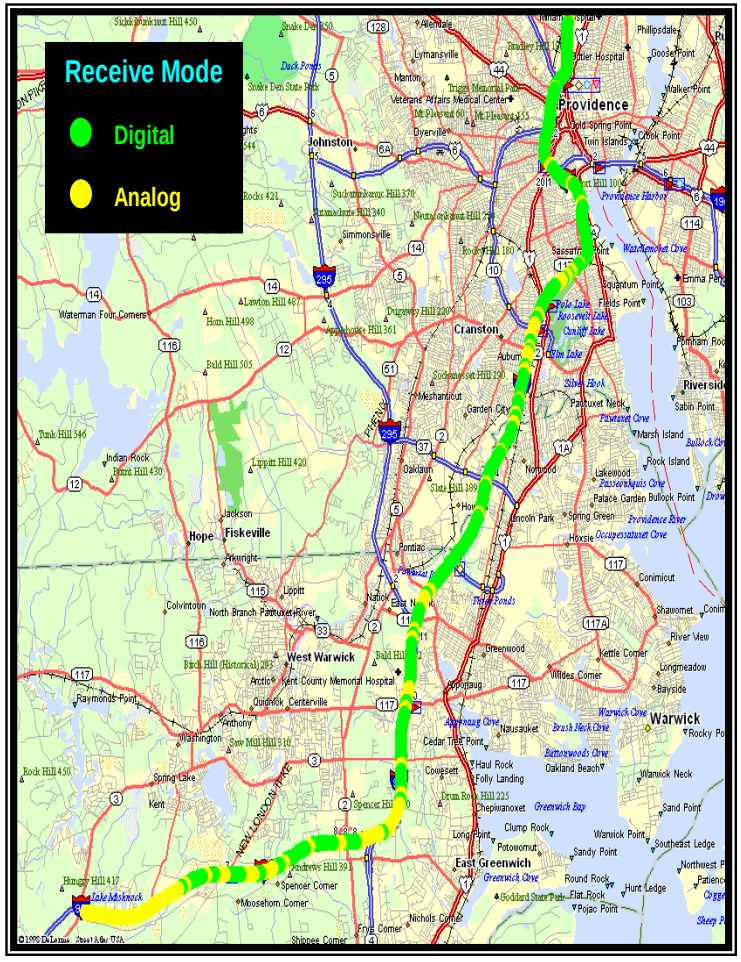


-13.75 dBc / -17 dBc (-12.1 dBc Total)

South Route (Away From Transmitter)



17 dBc / -17 dBc (-14 dBc Total)



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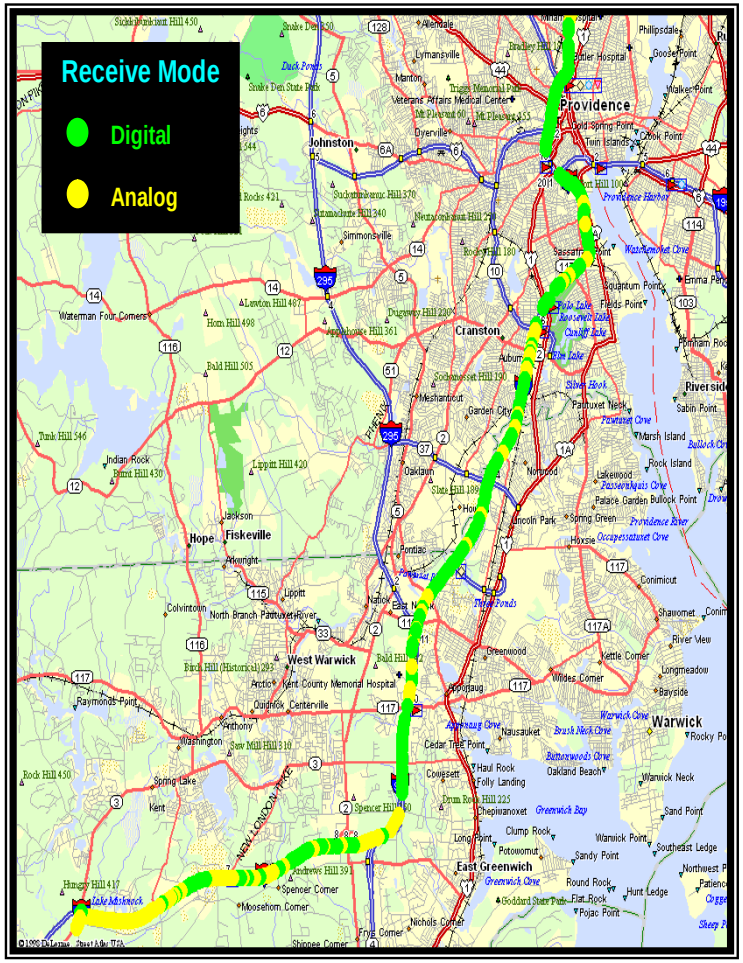

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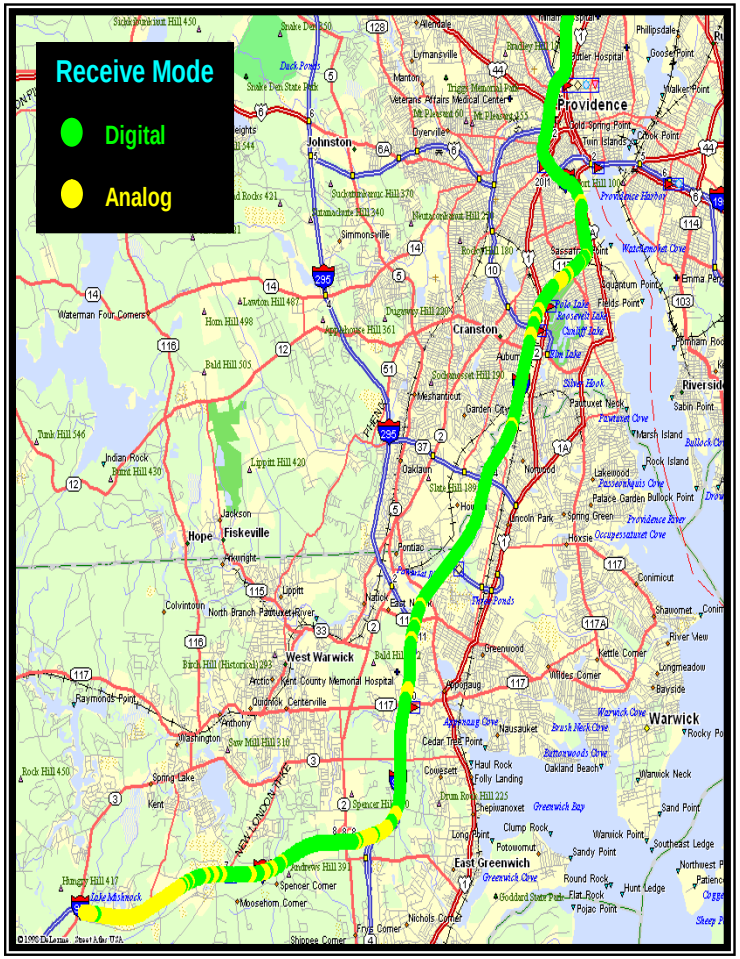
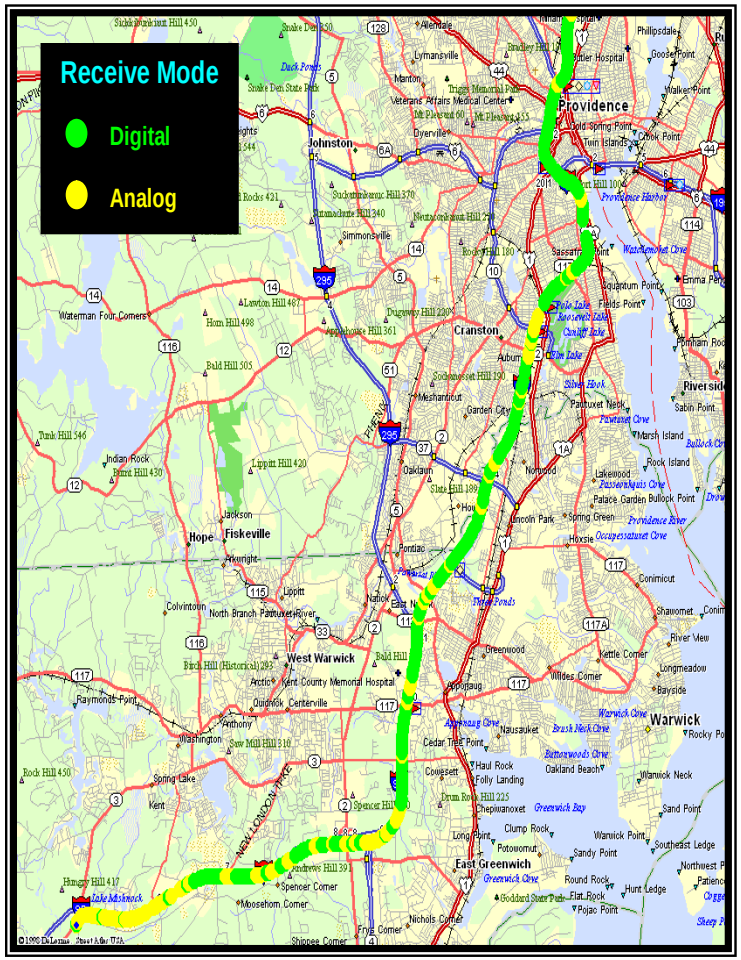


-13.75 dBc / -17 dBc (-12.1 dBc Total)

South Route (Toward Transmitter)



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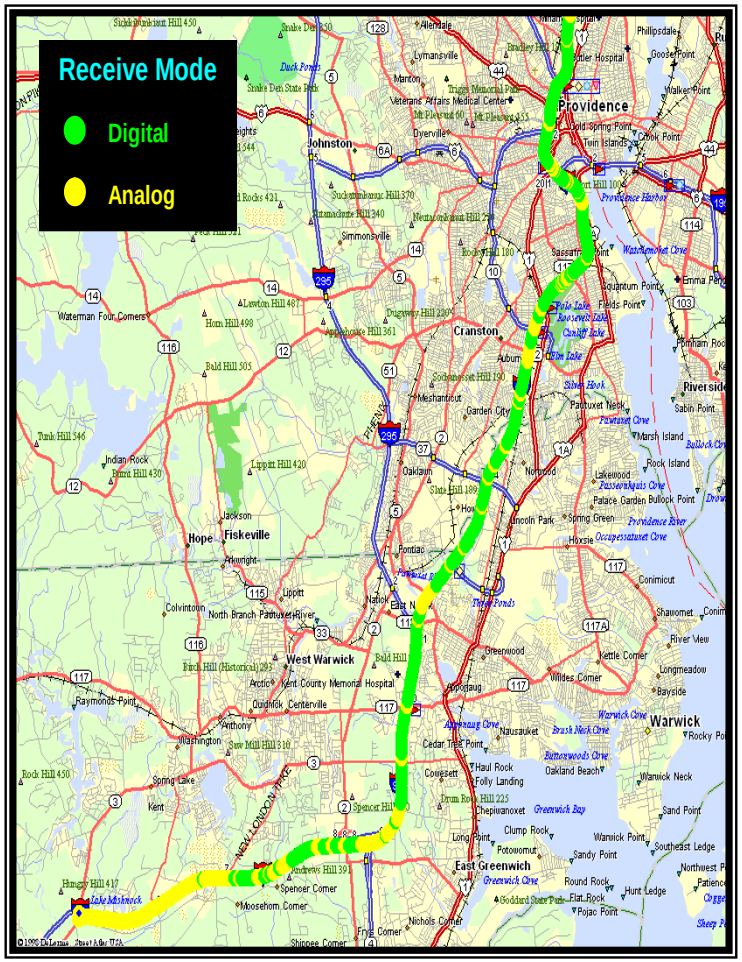

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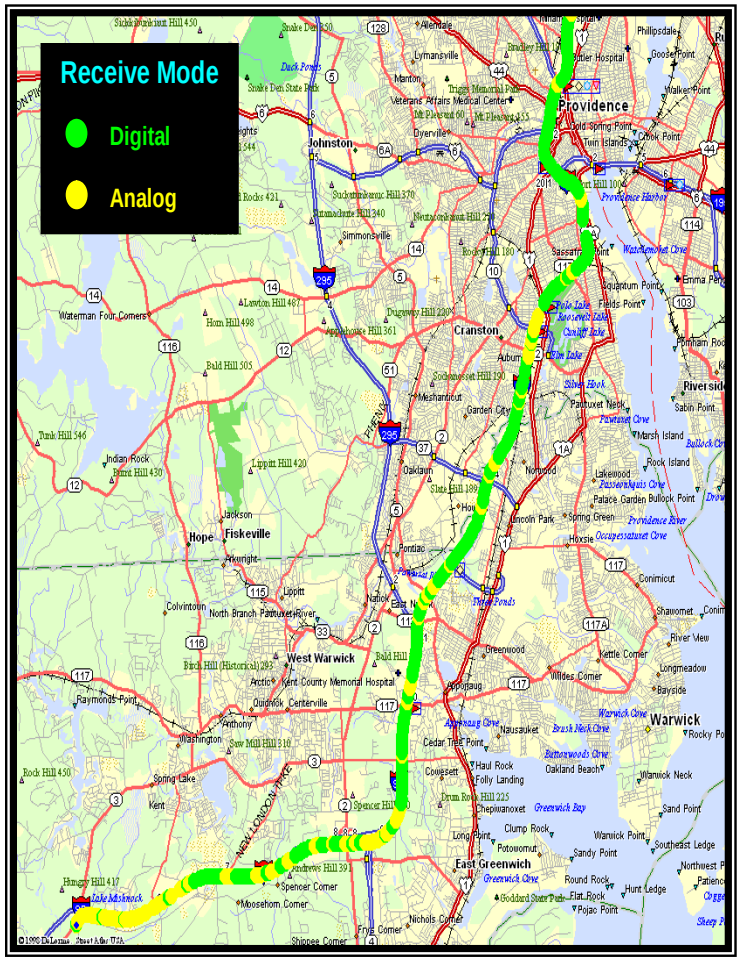

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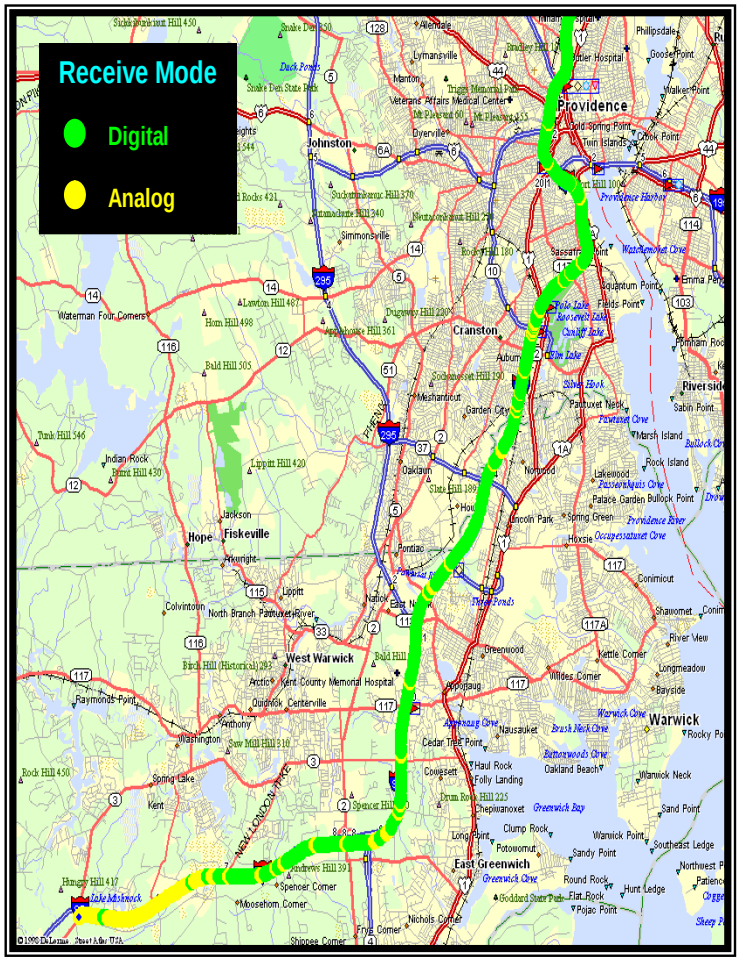


-13.75 dBc / -17 dBc (-12.1 dBc Total)

HD Radio Field Performance with Unequal Digital Sideband Carrier Levels

- Thanks To
  - NAB FASTROAD Project
    - David Layer
    - Lynn Claudy
  - Greater Media
    - Milford Smith
    - Paul Shulins & the Greater Boston Radio Crew

High Level IBOC Combining Methods for Single Input Antenna Systems

FCC has authorized increased FM IBOC symmetrical power levels from -20 dBc to -14 dBc for all FM stations without an application needed; just notification.

Authorization above -14 dBc up to -10 dBc symmetrical can be authorized with an application showing no interference.

Special Temporary Authority to operate asymmetrically with as much as 4 dB difference between the two groups may be authorized.

How can a higher TPO station efficiently increase digital power?

High Level IBOC Combining Methods for Single Input Antenna Systems

Nicholas A. Paulin and Thomas B. Silliman, P.E.
Electronics Research, Inc
Chandler, Indiana

Abstract - *Combining separate analog and HD Radio* *FM transmitters into a single antenna allows broadcasters to use existing equipment including transmitters, transmission line, and antennas; however, the options for accomplishing this are limited. A new method of high level analog/FM HD combining is discussed and compared to the other traditional methods.*

Efficient High Power IBOC Combining

Efficiencies Comparison

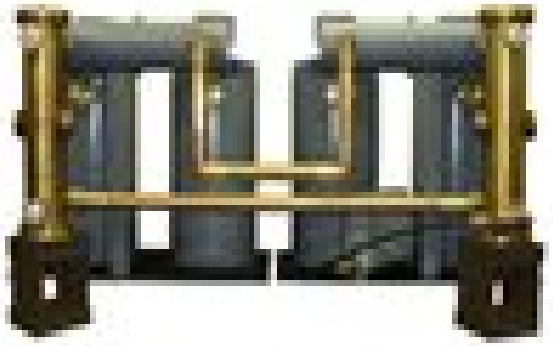
	FM Analog All Pass	FM HD All Pass	FM Analog Mask Filter	FM HD Mask Filter	FM Analog 10 dB Injector	FM HD 10 dB Injector
Input Power (dB from Analog Carrier)	0	-10	0	-10	0	-10
TPO Transmitter (Watts)	32,518	4,094	34,050	3,777	33,344	30,000
Integrated Loss (dB)	-0.35	-1.35	-0.55	-1	-0.46	-10
Efficiency	92.30%	73.30%	88.10%	79.40%	90.00%	10.00%
TPO Combiner (Watts)	30,000	30,000	30,000	30,000	30,000	30,000

Group Delay Comparison

Group Delay (MP3)	350 ns	600 ns	1.26 µs	9.87 µs	0 ns	0 ns

HD Radio®

Power Calculator for High Level IBOC Injection



70 YEARS
Of Broadcast Solutions
ERI®

http://www.eriinc.com/Catalog/Filters-Combiners/FM-Filters-Combiners/IBOC-Combiners.aspx

HD Radio®

HD Radio Feature Set

Digital Sound

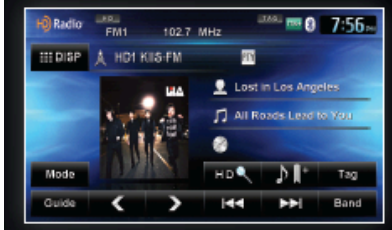
HD Radio broadcasts deliver crystal clear, CD-like digital audio quality to consumers.

PSD

Program Service Data provides song name, artist, station ID, and other relevant data streams.

Artist Experience

Visual images, such as album art of over-the -air broadcasts from HD Radio stations.



iTunes® Tagging

iTunes Tagging provides users the means to "tag" broadcast radio content for later review and purchase from the iTunes Store.

HD2/HD3

Adjacent to traditional main stations are HD2/HD3 Channels, providing new original formats on the FM dial.

Digital Traffic

HD Radio Digital Traffic delivers more in-depth traffic data and travel conditions – as much as 10x faster than other broadcast methods.

Channel Guide

Channel Guide displays all the HD Radio channels available in the current market, enabling the listener to discover all the digital programs available in the local area.

Bookmark

Bookmark is a music & product discovery feature that enables users to store information about content on the radio and delivers interactive information via QR codes.

Instant Info

News, sports, weather and more useful information at the touch of a button.

Active Alerts

Delivers critical and life saving messages to the public during emergency situations.

HD Radio®

This HD Radio receiver enables:

- PSD
- HD2/HD3
- Digital Sound
- iTunes® Tagging
- Artist Experience
- Live Pause
- Digital Traffic
- Bookmark

HD Radio®

HD Radio Feature Set

HD Radio®

This HD Radio receiver enables:

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- **Artist Experience**
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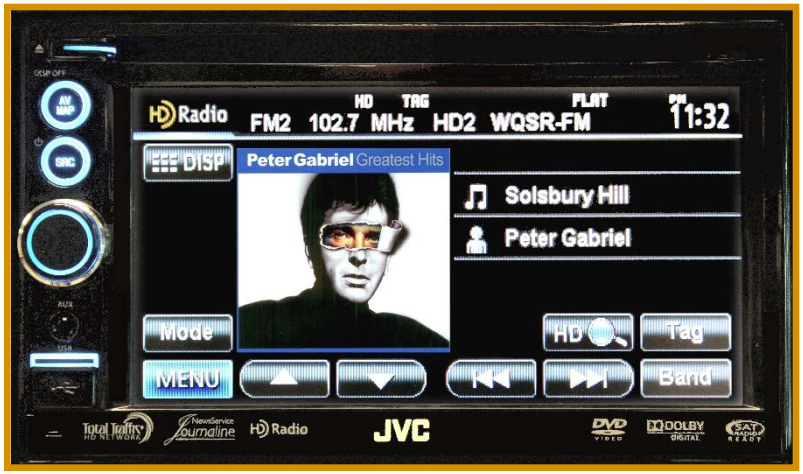
Artist Experience



Station Logos / Album Art / Advertiser Images

HD Radio®

Images over HD Radio

Station Logos


Album Art

Advertisements



Image Services

- HD Radio Technology offers a system enhancement that enables the transfer of image files over the HD Radio data transport.
- This capability will support the delivery and presentation of images that require synchronization with audio programming as well as those that are independent of the audio service.
- This will enable key features and applications such as Cover Art, Image Slide Shows, and Station Logos on a variety of HD Radio devices in different form factors.

HD Radio®

Three Image Delivery Services

These services are not mutually exclusive and can "co-exist" on a single HD Radio station and can be selectively implemented on receivers.

Station Logos

Audio Independent Images **–** The ability to transmit, receive, store and display images on an HD Radio receiver as they are received or based on an alternative rule set. Ability to send Station Logos for each multicast program.

Cover Art/Ad Images

Synchronized Images **–** The ability to transmit, receive, temporarily store and display images on an HD Radio receiver that are linked to primary or multicast audio services. Images will extend beyond album art to provide multi media experience across a range of audio programming.

Image Services

Large Scalable Images **–** These are image based services that are characterized by their large file size and the ability for a segment or portion of the image to be "scaled" or "zoomed" to provide more detailed imaging, for example: traffic maps, weather maps, etc

What needs to be done for:

Artist Experience

Contact transmission equipment vendor for latest broadcast software releases to support Artist Experience and Station Logo services.

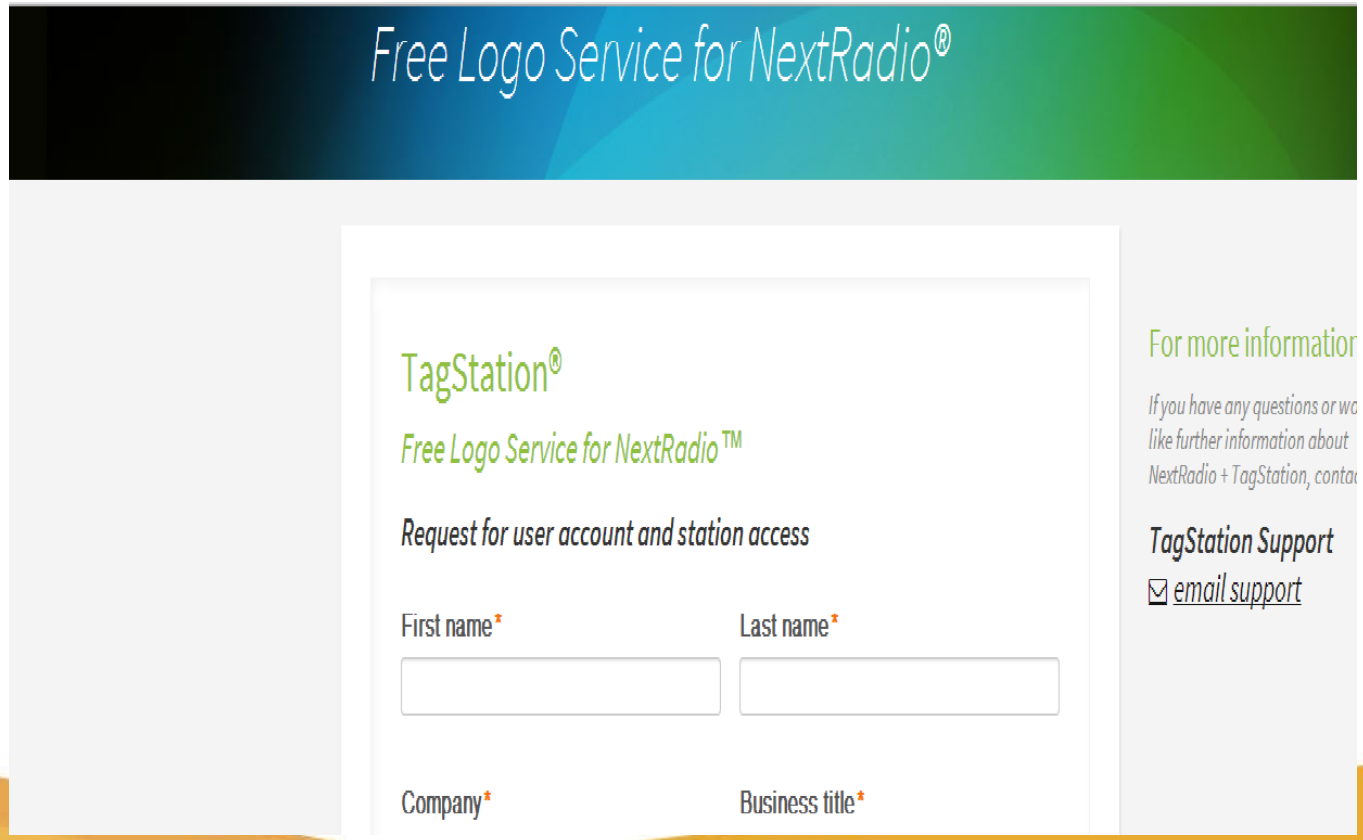
- Importer Software (v4.3.1 P1 (database patch) or later)
- Image Support Client
- Exporter Software (v4.3.2 or later)

- Latest PSD automation tool
- Automation software that supports Artist Experience & licensed images

HD Radio®

Free Station logo Service from TagStation

- Easy way to get the station's logo images populated. (http://tagstation.com/free/)
- If station has the required software for HD Radio Artist Experience, this will enable logos on the HD broadcast as well.



AM Digital HD Radio

Have there been any technical advancements for AM IBOC?

Reduced digital bandwidth, Hybrid Mode

Renewed interest in the All-Digital Mode

Reduced Digital Bandwidth (Core Only) "Compatibility Mode"

Broadcaster Benefit

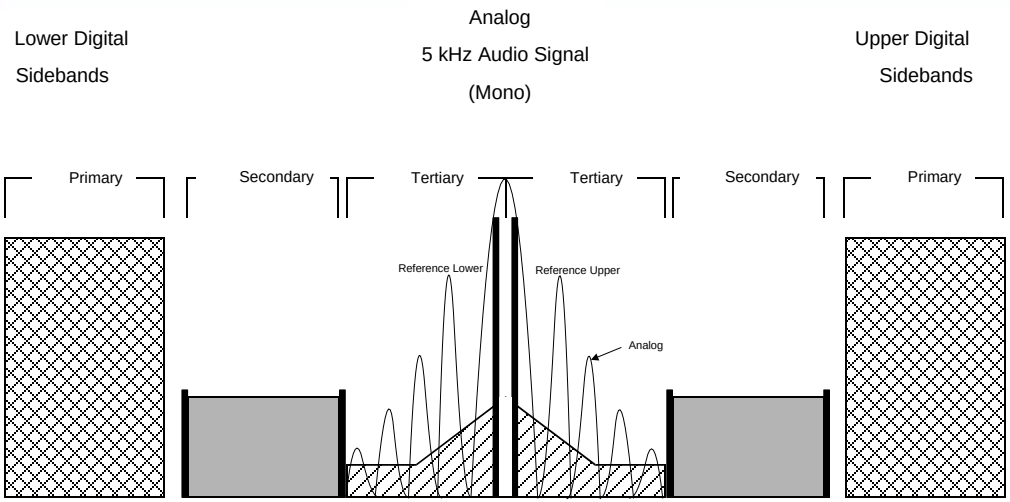
- Significant reduction of potential host noise
- Parametric stereo audio meets market expectation of digital

Consumer Benefit

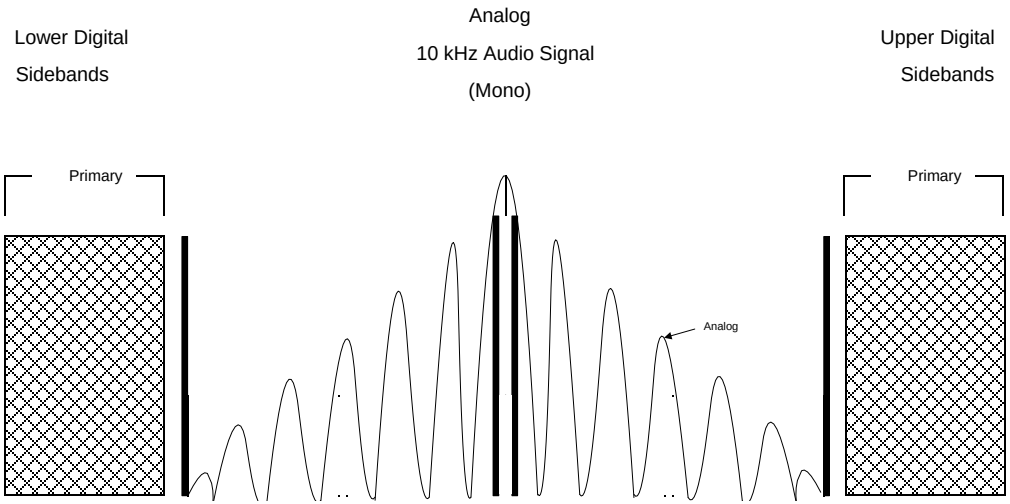
- Reduction of Core/Enhanced and analog blends
- Uniform audio experience to digital point of failure

Available in MPS Framework v4.3.2P5 and subsequent releases

MA1 Single Stream Reduced Bandwidth Configuration



Full MA1 Core/Enhanced Stream
5 kHz analog bandwidth

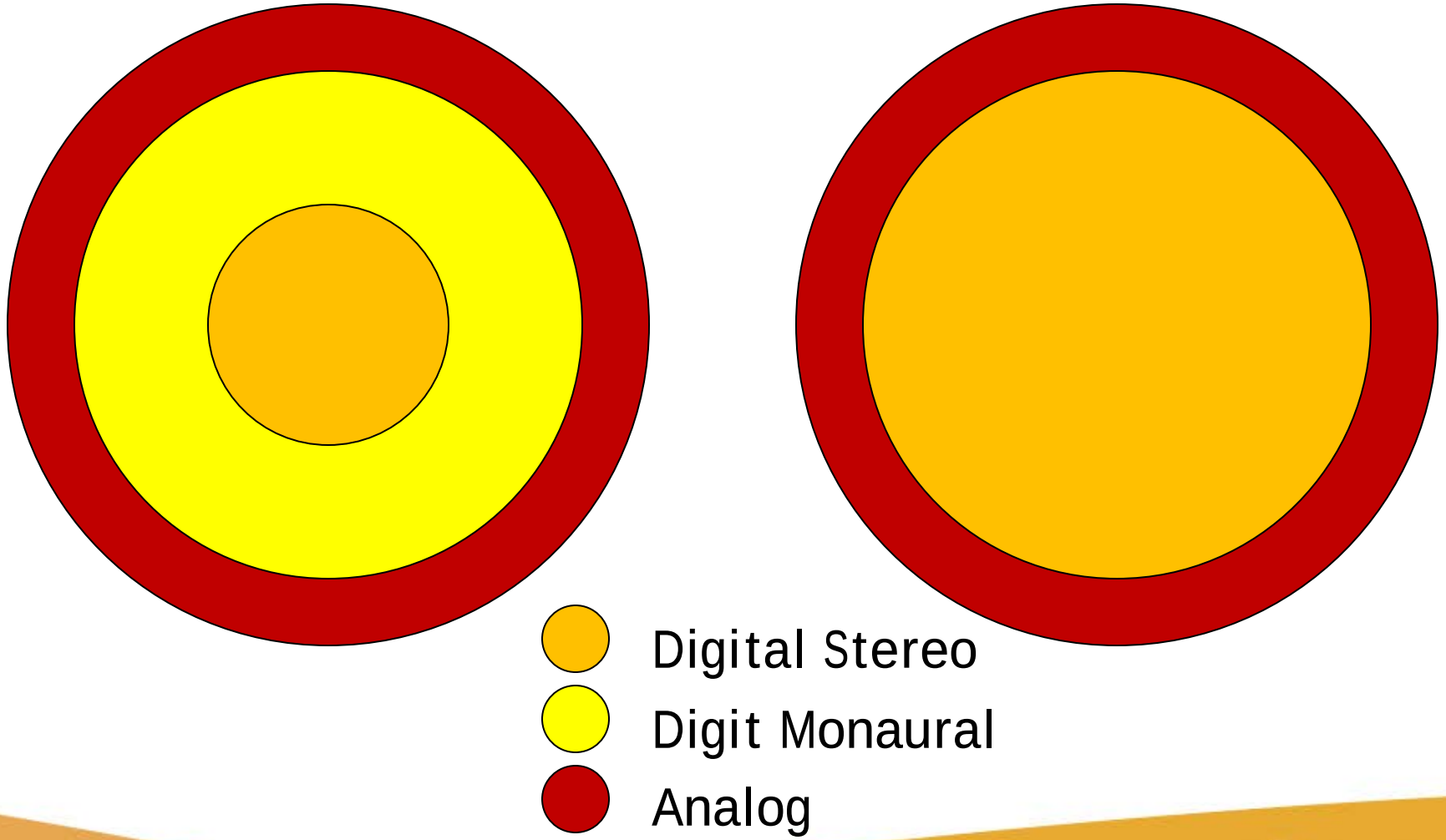


MA1 Reduced Bandwidth Configuration
10 kHz analog bandwidth

Comparison of Audio Performance

Full MA1

MA1 Reduced Digital Bandwidth



HD Radio®

MA1-P1 Low Interference Mode, Harris Summary

With the Release of Dexstar v.4.3.2 there is a new configuration option for AM Hybrid mode. This mode allows for the elimination of the Enhanced (Secondary & Tertiary) HD Radio carriers which permits:

- The use of up to 10kHz analog audio bandwidth
- Positive peak modulation in excess of 125%
- Better performance with compromised +/-5kHz antenna symmetry.
- A SNR improvement in nearly all radios
- ~10 dB SNR improvement in worst offending pre-2003 radios
- ~6 dB SNR improvement in post-2003 radios
- Improved analog host compatibility
- More uniform digital stereo coverage with parametric stereo
- Eliminates Core/Enhanced blends
- More uniform audio experience to the end of digital coverage

MA1 Reduced Bandwidth Configuration10 KHz analog bandwidth, capable of 20 KB/S digital bandwidth

HD Radio®

Configuration Information

For the latest Core Mode configuration specific to your transmitting gear…

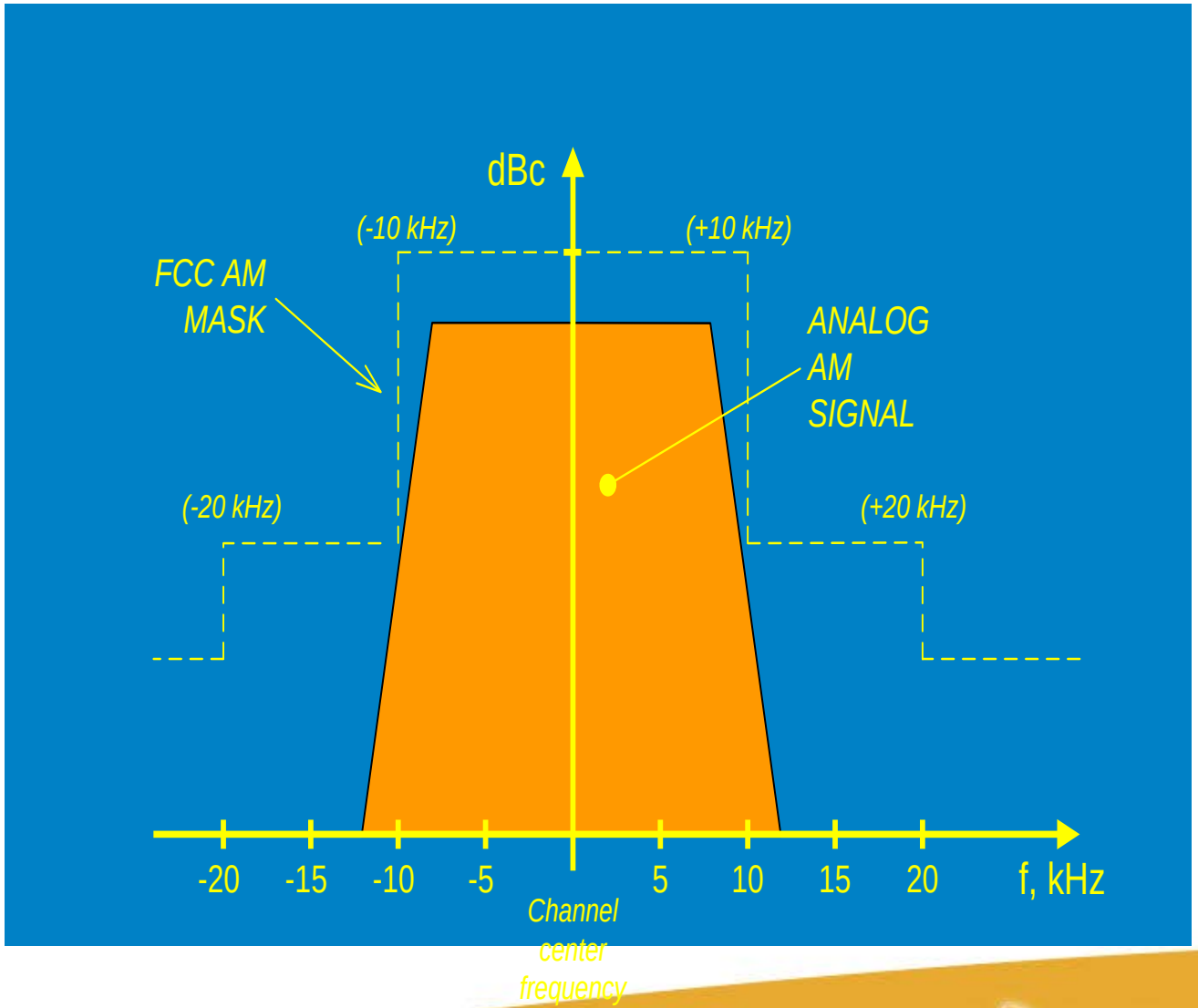
Email Tom Walker at iBiquity
walker@ibiquity.com

Tom keeps track of the latest updates from the manufacturers.

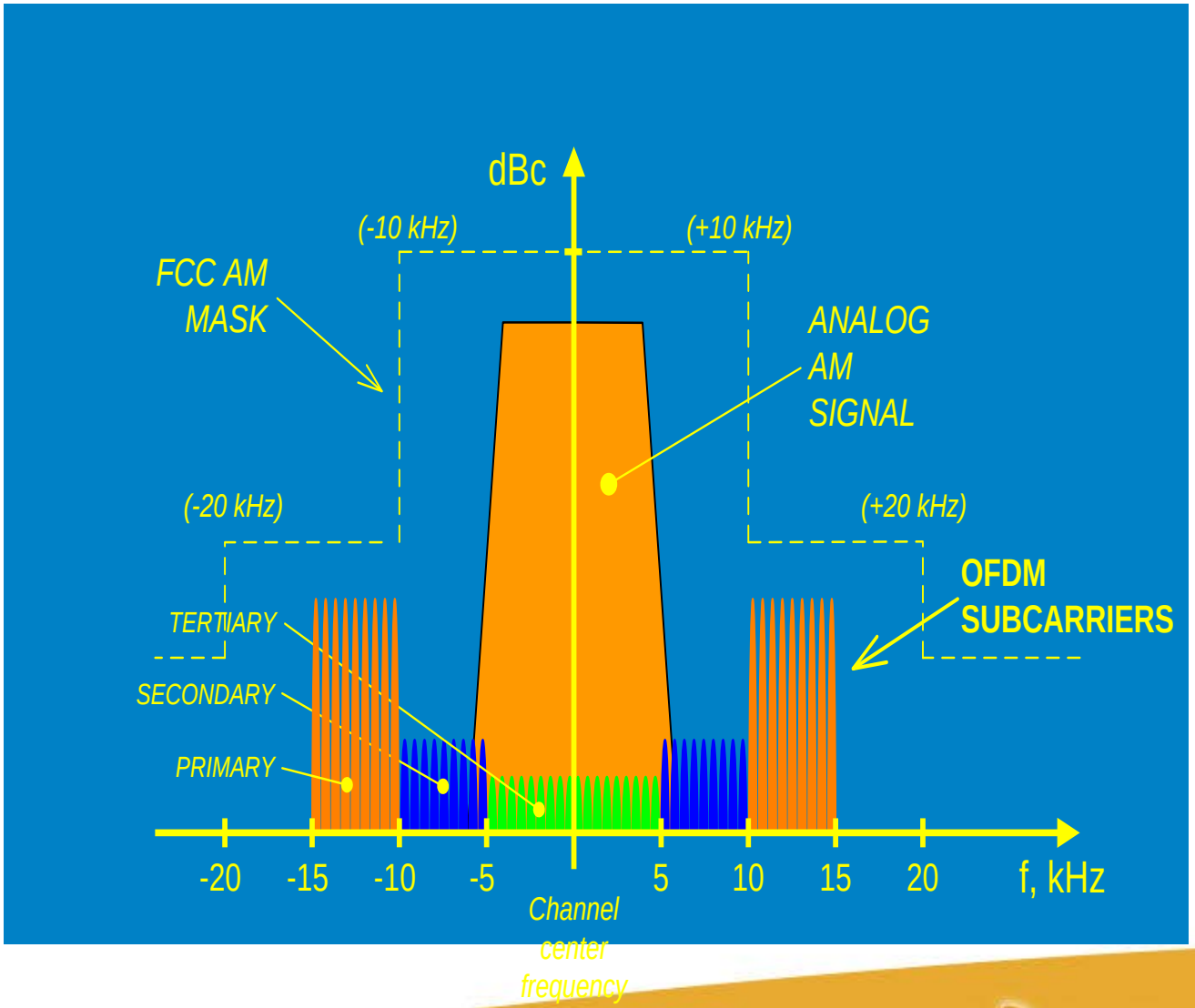
All-digital AM

David Layer, Senior Director, Advanced Engineering, NAB

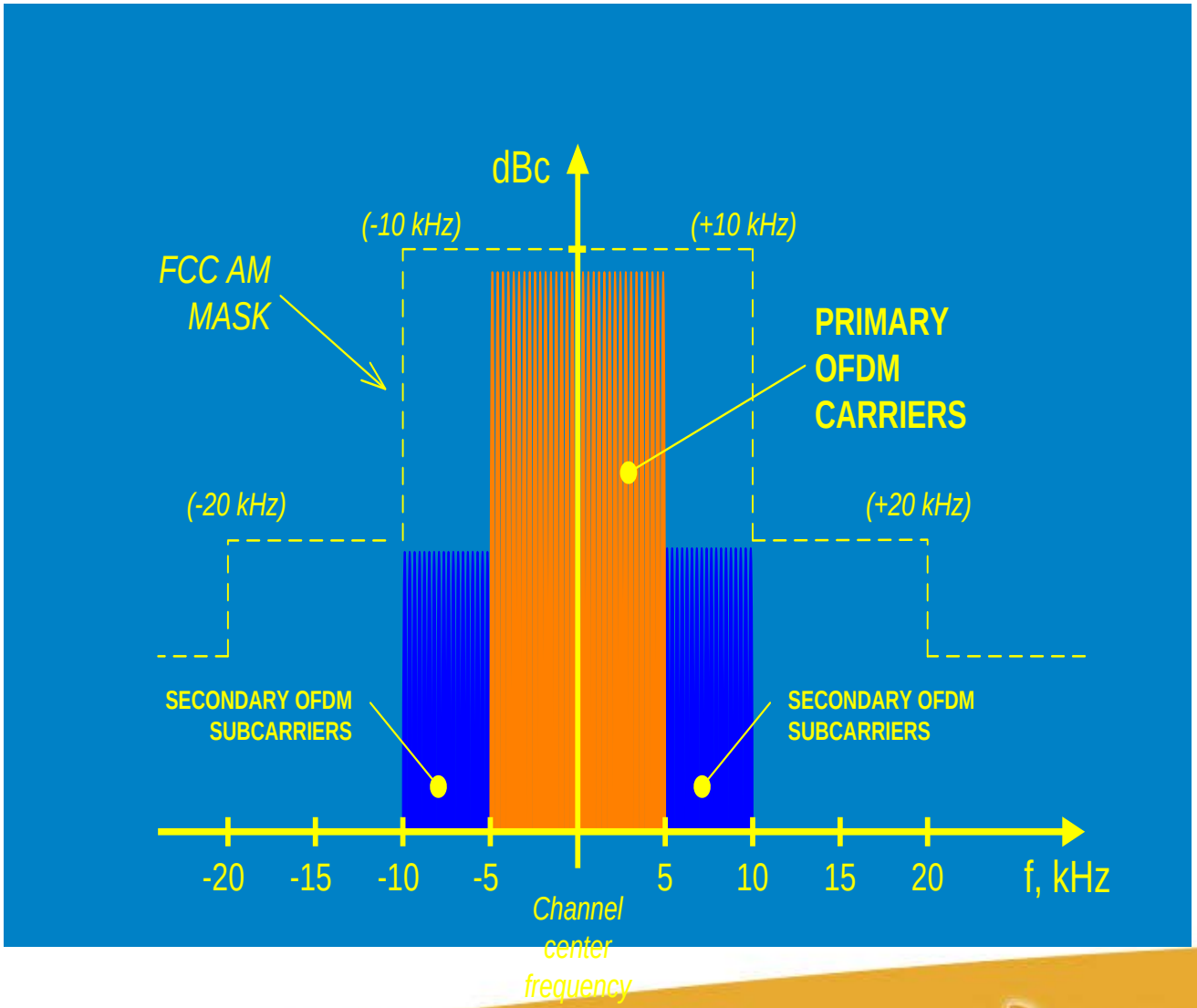
- Analog AM signal



- Hybrid AM IBOC signal



- All-digital AM IBOC signal

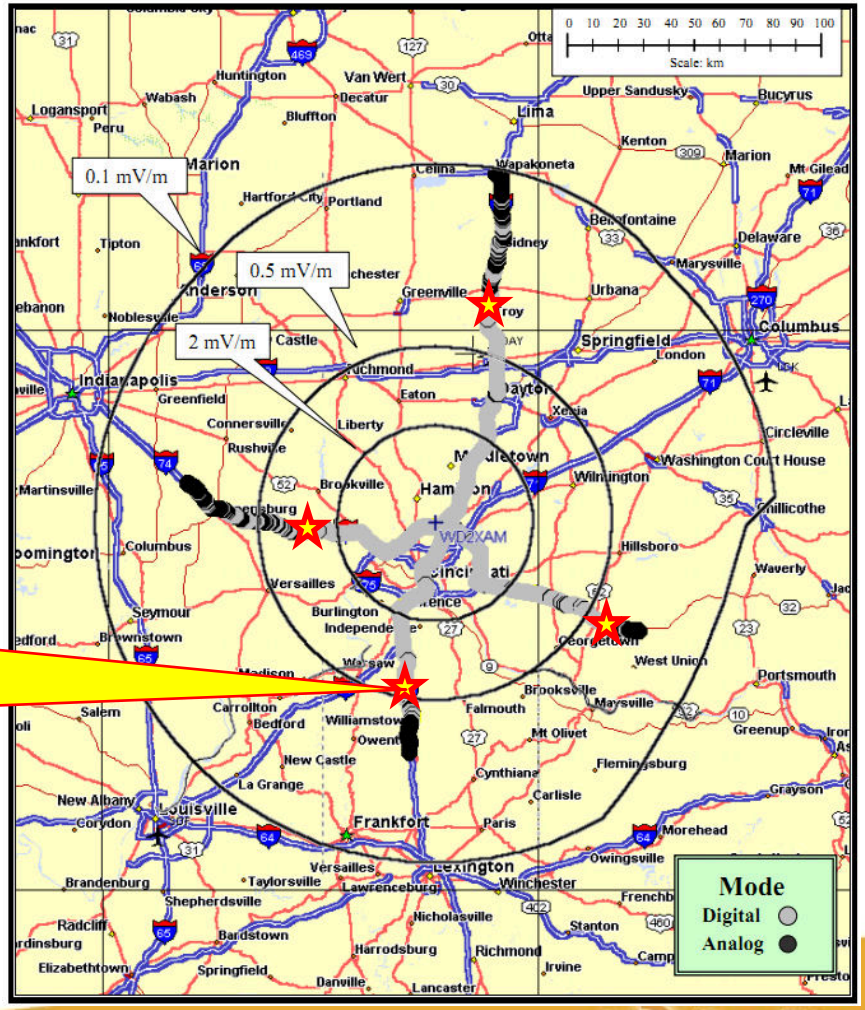


All-digital AM

- Principal drawback – all-digital signal not receivable on analog-only radios
  - Requires significant penetration of HD Radio receivers in marketplace
- Another issue – all-digital is not authorized by the FCC
  - Very little testing on all-digital IBOC to-date
  - First step in getting FCC authorization is to develop a technical record of all-digital system performance

Hybrid AM IBOC

- From 2002
- Daytime coverage – WD2XAM, Cincinnati, OH
- Coverage to approx. 0.5 mV/m



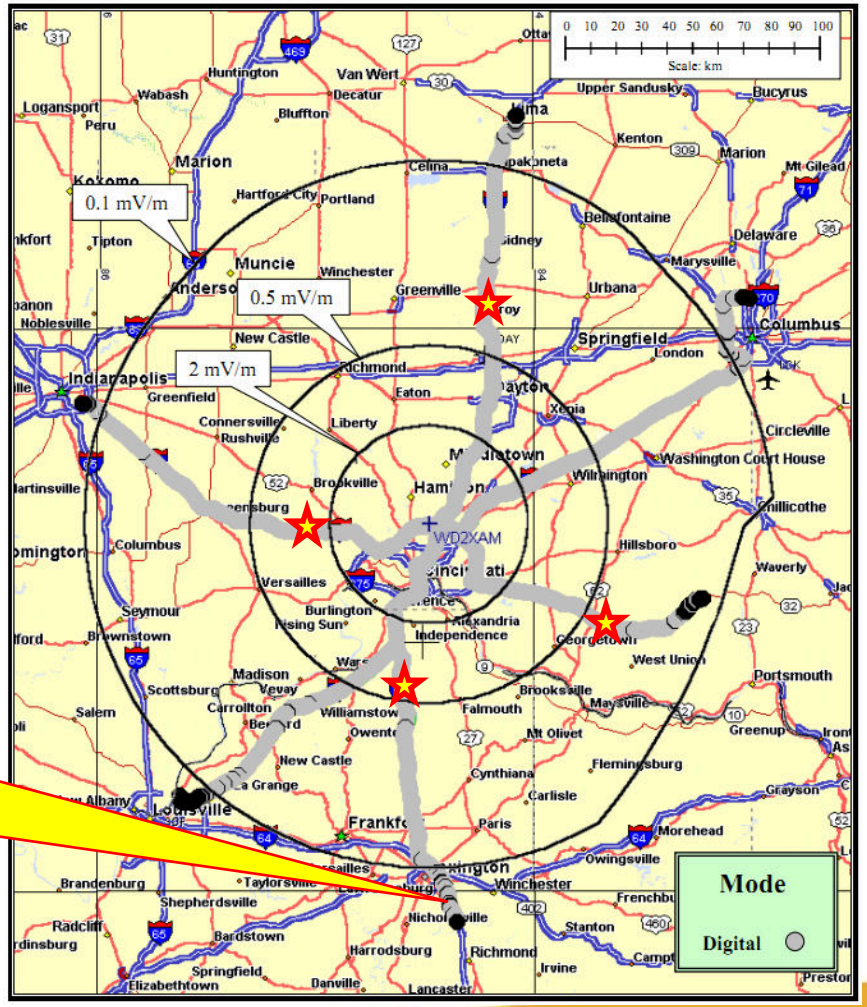
GRAY LINES SHOW EXTENT OF DIGITAL COVERAGE

HD Radio®

All-digital AM IBOC

- From 2002
- Daytime coverage – WD2XAM, Cincinnati, OH
- Coverage to approx. 0.1 mV/m

GRAY LINES SHOW EXTENT OF DIGITAL COVERAGE



HD Radio®

All-digital AM testing

- NAB Labs testing project
- Partners:
  - iBiquity Digital Corporation – Nautel
  - CBS Radio – Harris Broadcast
  - Beasley Broadcast Group – BE
  - Greater Media – Kintronic Labs
  - Cavell, Mertz & Associates
  - Meintel, Sgrignoli & Wallace

All-digital AM testing

- Testing to-date:
  - WBCN – 1660 kHz, Charlotte, NC *(Dec 2012)*
  - WNCT – 1070 kHz, Greenville, NC *(July 2013)*
  - WBT – 1110 kHz, Charlotte, NC *(Aug 2013)*
- WBCN results discussed at 2013 NAB Broadcast Engineering Conference

WBCN All-digital AM IBOC Field Test Project

David H. Layer
National Association of Broadcasters
Washington, DC

Alan Lane
CBS Radio
Charlotte, NC

Russ Mundschenk
iBiquity Digital Corporation
Columbia, MD

E. Glynn Walden
CBS Radio
Philadelphia, PA

Dennis Wallace
Meintel, Sgrignoli & Wallace
Waldorf, MD

Tom King
Kintronic Labs
Bluff City, TN

Abstract – *CBS Radio AM station WBCN, 1660 kHz, Charlotte, NC, obtained an experimental license from the FCC in late 2012 for operation in the iBiquity in-band/on-channel (IBOC) HD Radio all-digital MA3 mode. A project team consisting of NAB L... CBS Radio and iBiquity calibrat... this all-digi... mission and then made daytim... ...ht... ...verage meas...ements for both ... ... Thi... describes the test ... ...esults obtained*

FULL PAPER AVAILABLE IN THE 2013 NAB BEC PROCEEDINGS

...ital radio ...orporation and ...Committee ...adamental ... hybrid ..., which utilizes a radio ...the legacy a...log signal (AM or FM), ...horized ...use in the U.S. by the FCC in 2002, and at p...esent over 2,200 radio stations are broadcasting a hybrid HD Radio signal.

iBiquity and others have contemplated that the transition to digital radio using the HD Radio system could encompass two phases: the introduction of digital radio

by iBiquity on the all-digital AM IBOC system, from 2002 [4], documents field testing and "...highlights the improved performance that will be achieved by converting from the IBOC hybrid mode to all-digital broadcasting." [2]

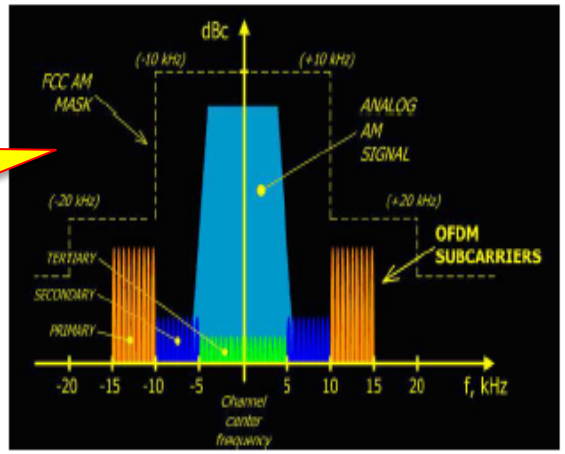
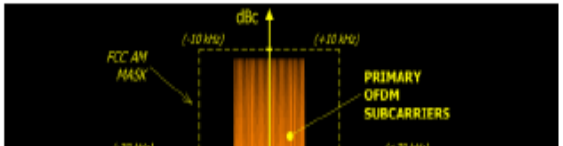


FIGURE 1. HYBRID AM IBOC SIGNAL SPECTRUM

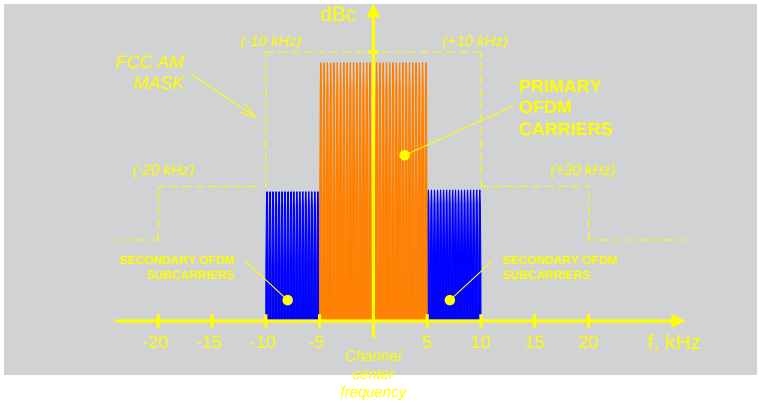


Disclaimer

- These are PRELIMINARY results
  - EXPANDED BAND (less interference)
  - NON-DIRECTIONAL STATION
  - 10 kW day / 1 kW night
  - SINGLE-STATION TEST
- Additional data is needed to fully understand the capabilities of all-digital AM IBOC

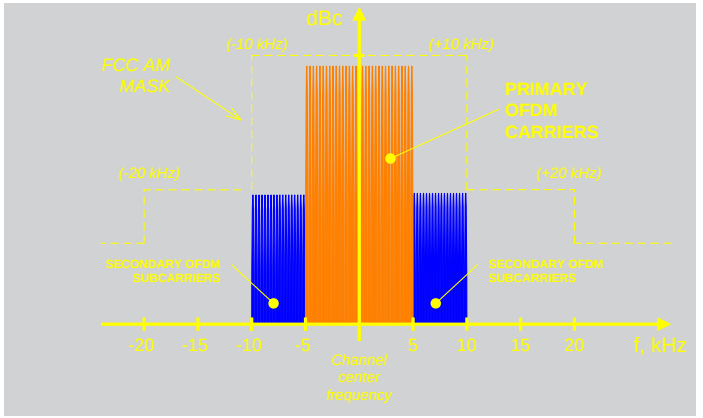
WBCN field test project

- Goals:
  - Develop transmitter calibration procedures
  - Establish coverage area of all-digital signal
  - Conduct indoor tests of all-digital signal
- Project team:
  - NAB Labs
  - CBS Radio
  - iBiquity Digital Corporation



WBCN field test project

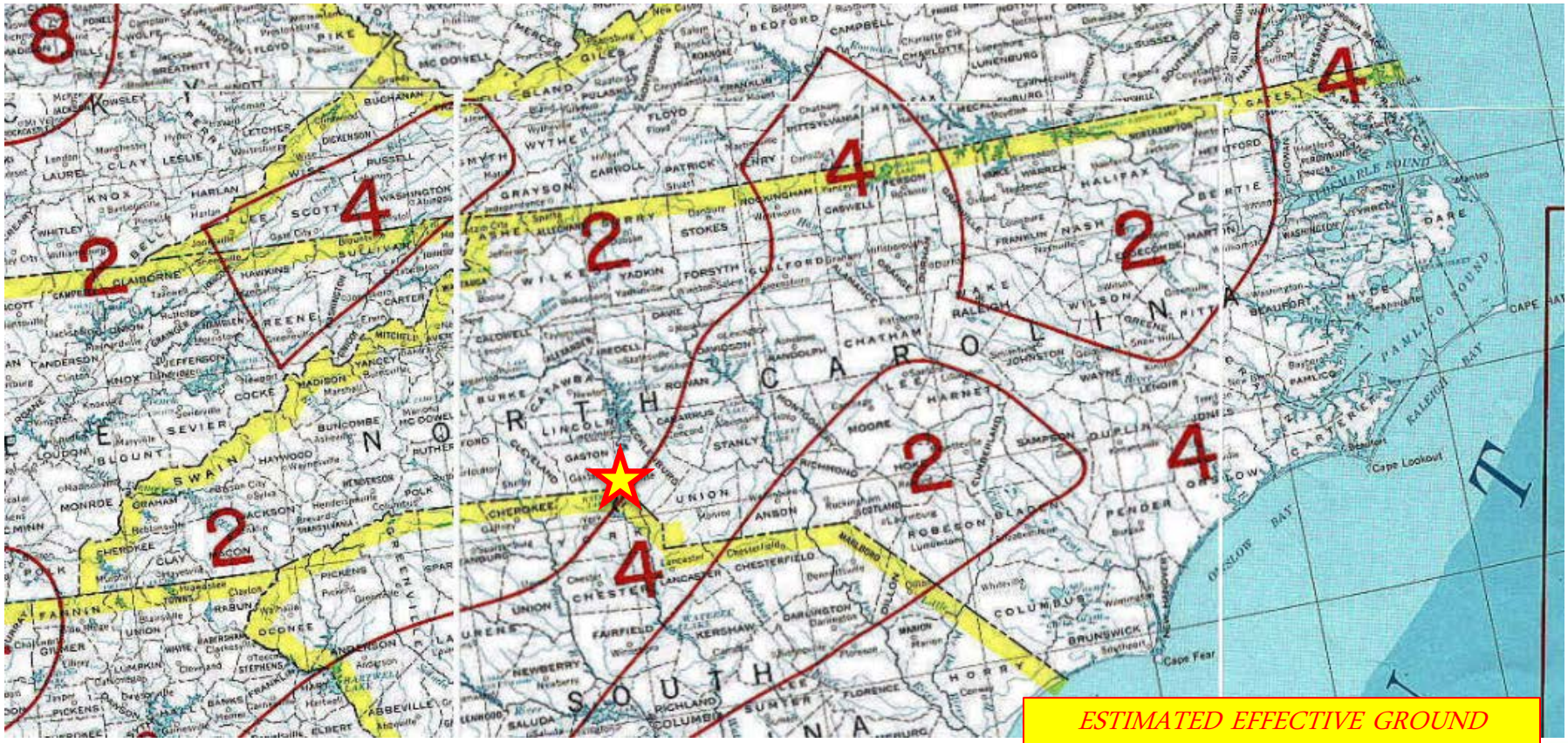
- Station used for testing:
  - WBCN 1660 kHz (expanded band)
  - Charlotte, NC
  - Owner: CBS Radio
  - 10 kW day, 1 kW night, non-directional
  - Harris DX-10 transmitter, Dexstar exciter



Charlotte, NC

HD Radio®

FCC Figure M3



ESTIMATED EFFECTIVE GROUND CONDUCTIVITY IN MILLIMHOS PER METER


DX 10
OPTIMOD-AM

WBCN field test project

- Two trips:
  - November 23-28, 2012
  - December 7-15, 2012
- Data collected:
  - Transmitter calibration data/procedure
  - All-digital reception (OEM receiver) out to point of failure (POF) – 7 test routes (daytime), 8 test routes (nighttime)

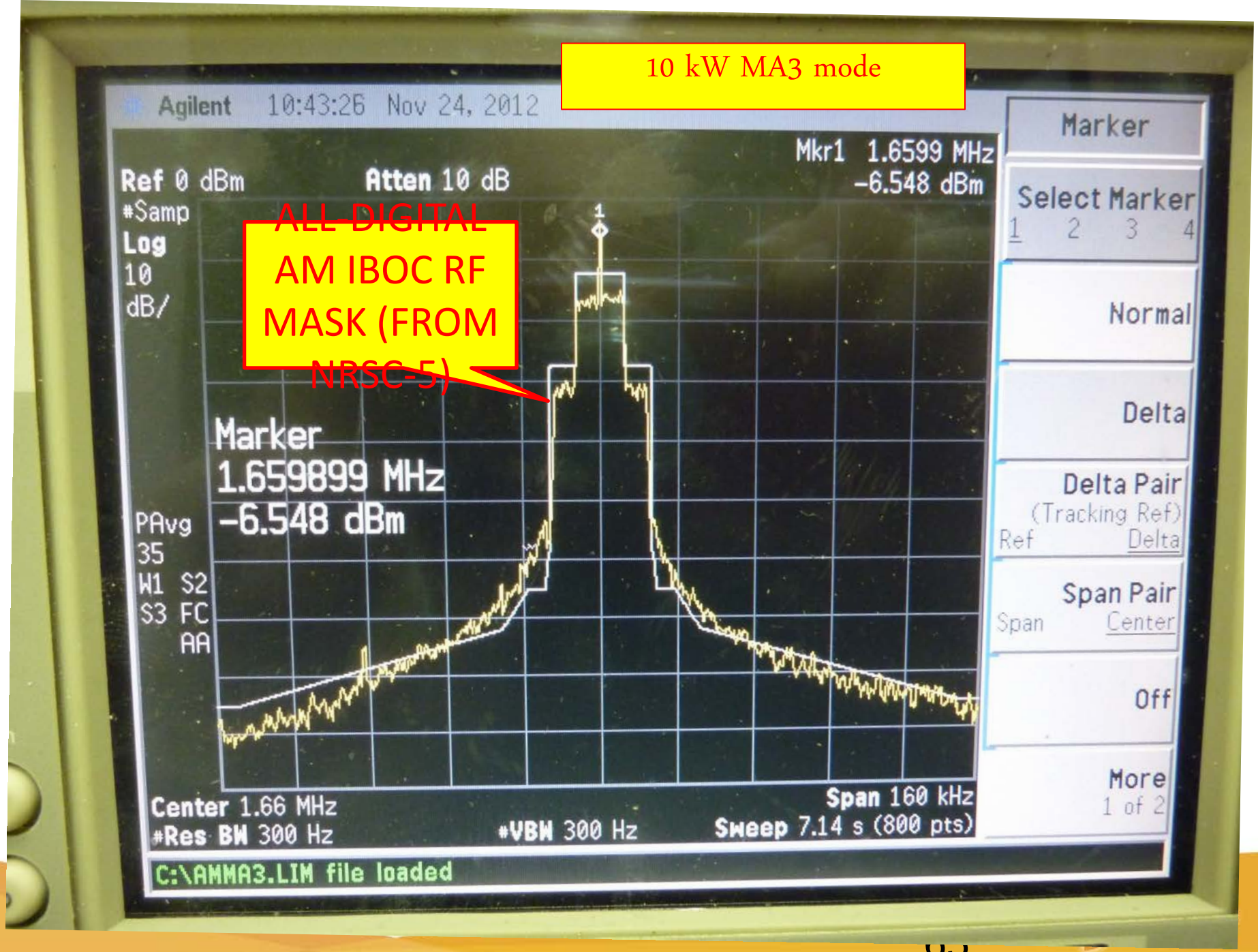
All-digital AM IBOC field testing

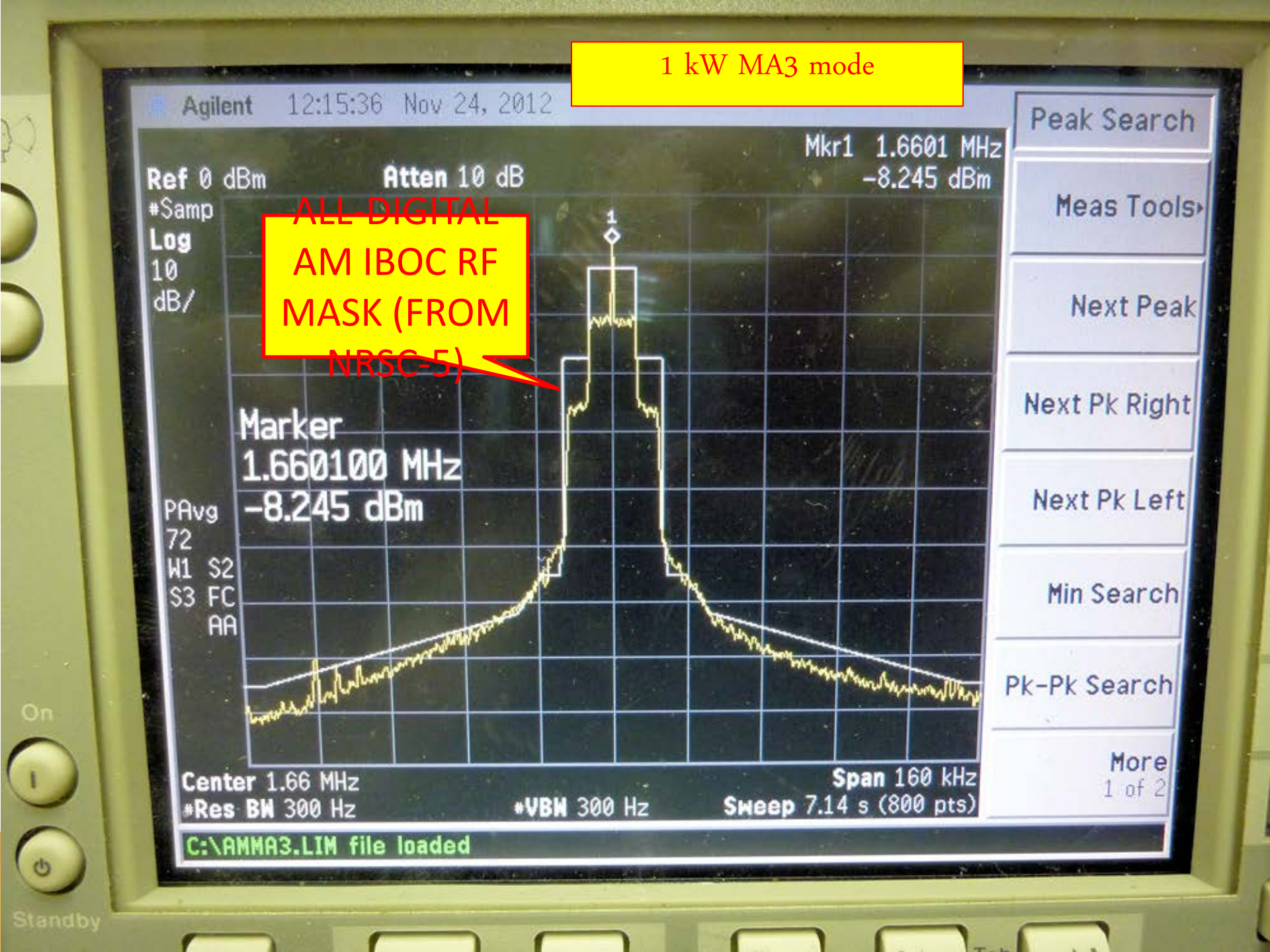
- Data collected (cont.):
  - Audio recordings of analog signal (OEM receiver) at all-digital POF for all test routes (15 recordings)
  - Audio recordings of indoor reception using Insignia Narrator (analog, digital, day, night)
  - Signal strength measurements

All-digital AM IBOC field testing

- Transmitter calibration results:

	10 kW (daytime) operation		1 kW (nighttime) operation	
Parameter	**Analog**	**Digital (MA3)**	**Analog**	**Digital (MA3)**
Forward power as indicated on DX-10 (kW)	10.0	7.81	1.0	0.8
PA current as indicated on DX-10 (A)	54	51	9	9
Antenna base current (A)	11.8 (carrier only)	10.6	3.75	3.4
Dexstar I/Q scale factor	n/a	8000	n/a	7800
Dexstar magnitude / phase delay	n/a	12915	n/a	12935

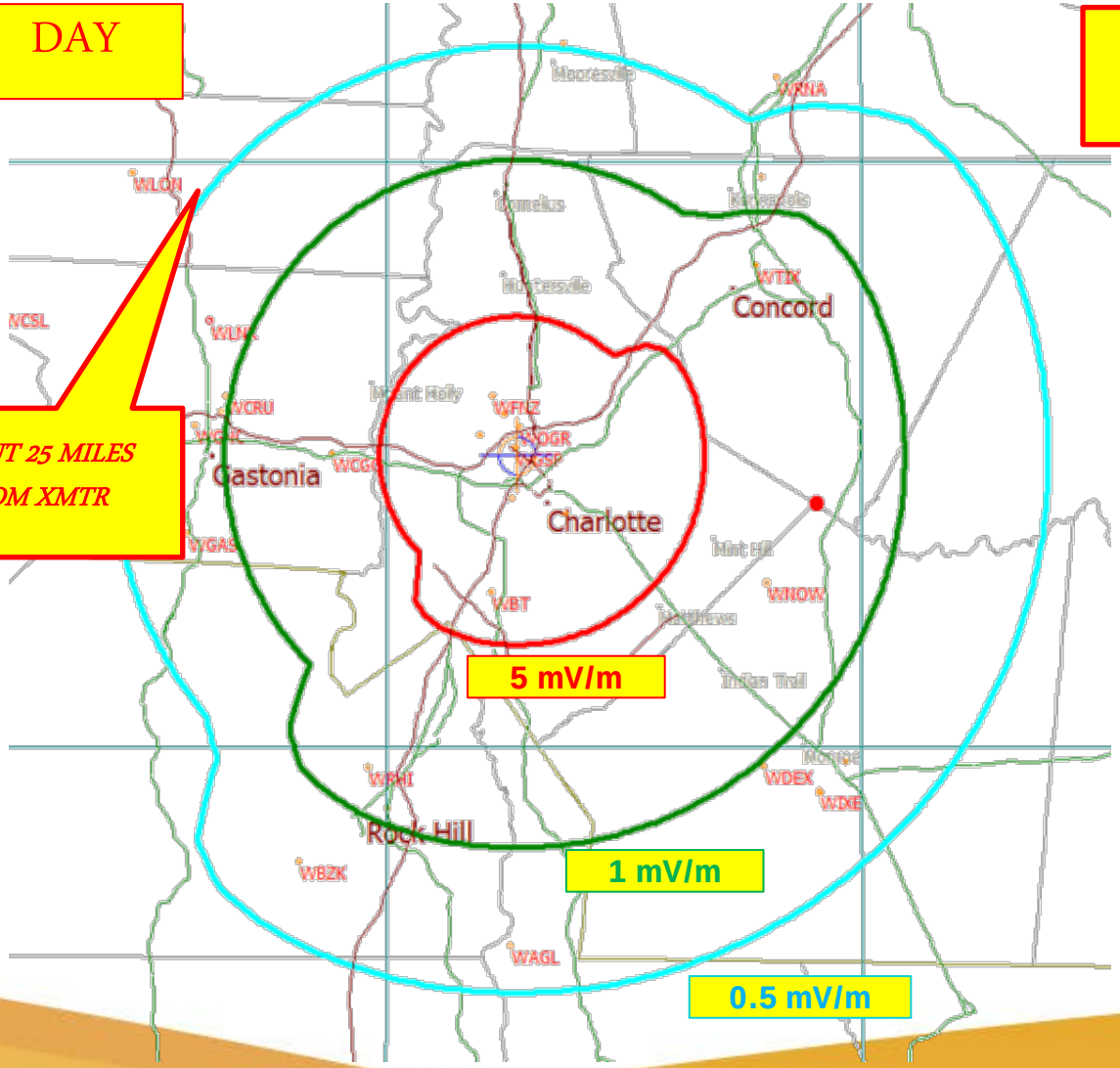

10 kW MA3 mode
Agilent 10:43:26 Nov 24, 2012
Ref 0 dBm
Atten 10 dB
Mkr1 1.6599 MHz
-6.548 dBm
#Samp
Log
10
dB/
ALL-DIGITAL AM IBOC RF MASK (FROM NRSC-5)
Marker
1.659899 MHz
-6.548 dBm
PAvg
35
W1 S2
S3 FC
AA
Center 1.66 MHz
#Res BW 300 Hz
#VBW 300 Hz
Span 160 kHz
Sweep 7.14 s (800 pts)
C:\AMMA3.LIM file loaded
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2


1 kW MA3 mode
Agilent 12:15:36 Nov 24, 2012
Ref 0 dBm
Atten 10 dB
Mkr1 1.6601 MHz
-8.245 dBm
#Samp
Log
10
dB/
ALL-DIGITAL AM IBOC RF MASK (FROM NRSC-5)
Marker
1.660100 MHz
-8.245 dBm
PAvg
72
W1 S2
S3 FC
AA
Center 1.66 MHz
#Res BW 300 Hz
#VBW 300 Hz
Span 160 kHz
Sweep 7.14 s (800 pts)
C:\AMMA3.LIM file loaded
Peak Search
Meas Tools
Next Peak
Next Pk Right
Next Pk Left
Min Search
Pk-Pk Search
More
1 of 2
On
Standby

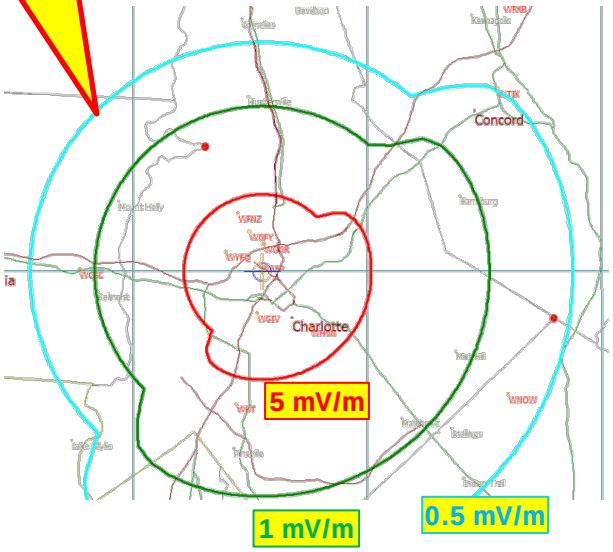
Analog coverage area - day/night comparison

DAY

ABOUT 25 MILES FROM XMTR

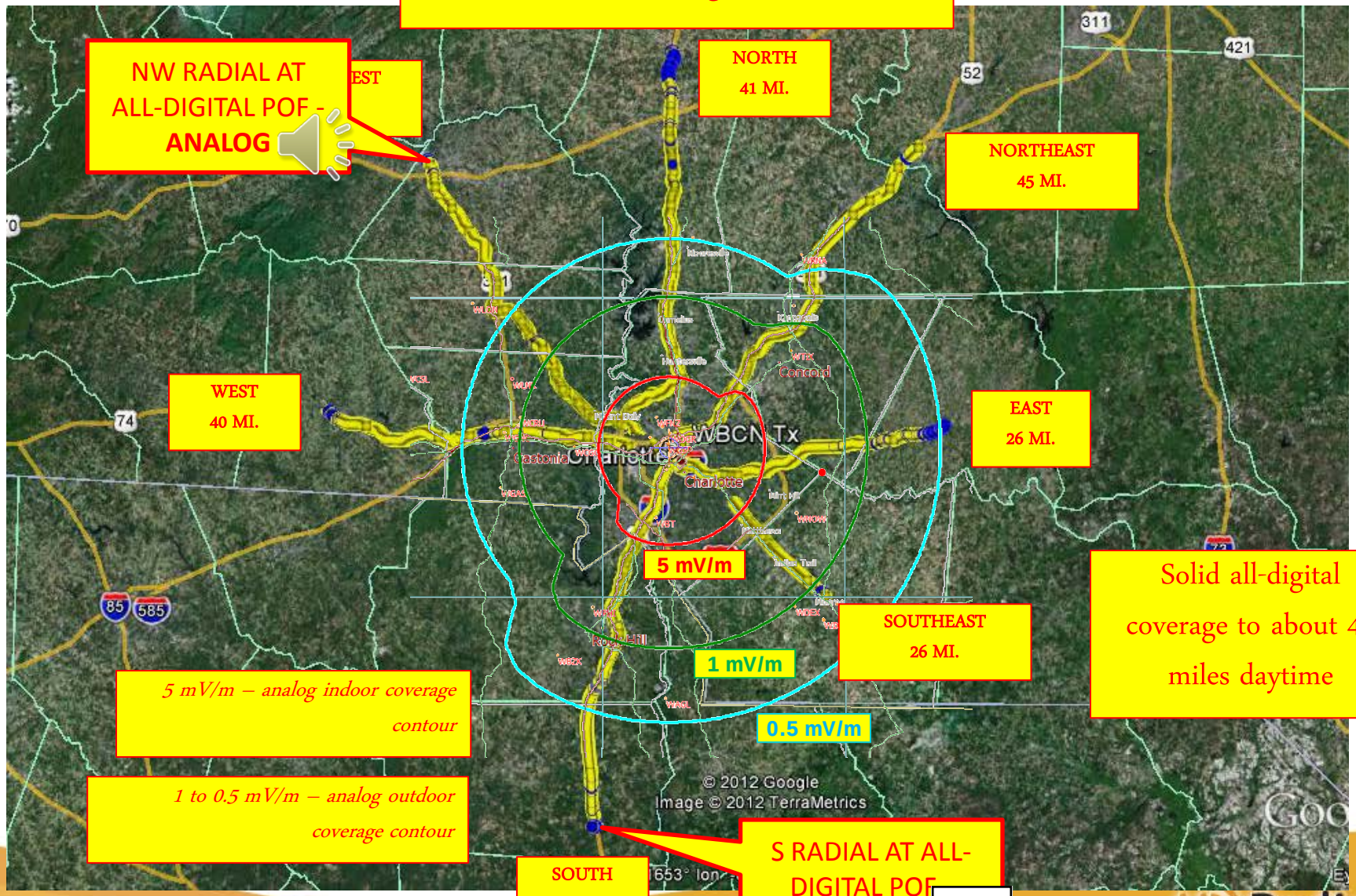


ABOUT 12 MILES FROM XMTR

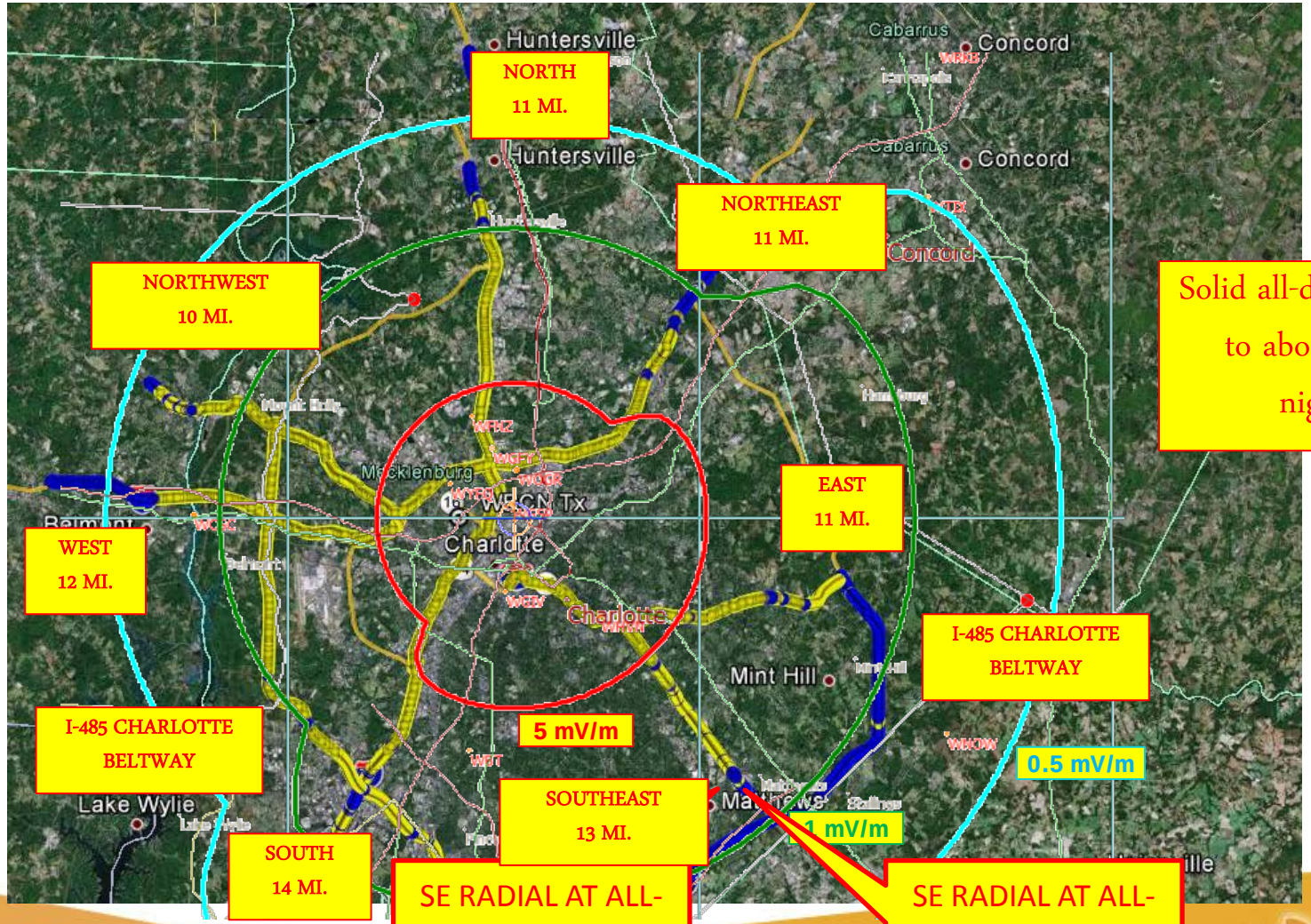


NIGHT

10 kW MA3 mode – daytime coverage



1 kW MA3 mode – nighttime coverage

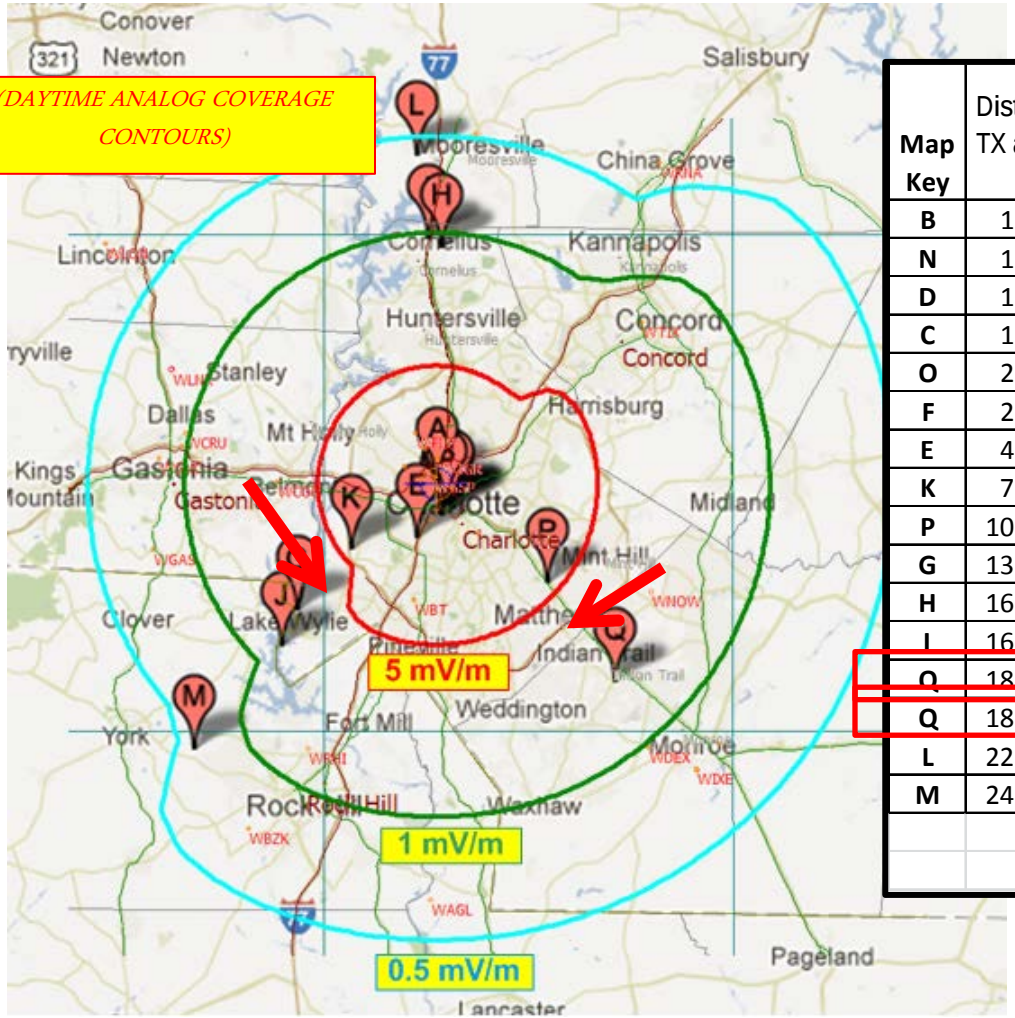


Solid all-digital coverage to about 11 miles nighttime

SE RADIAL AT ALL-DIGITAL POF
ANALOG

SE RADIAL AT ALL-DIGITAL POF
DIGITAL

Indoor test results



Map Key	Distance to TX antenna (mi)	Description	AD	AN	DD	DN
B	1.66	Bank of America Stadium	G	G/F		
N	1.69	Residence Inn by Marriott	G	G/F		
D	1.83	CBS Radio - "Doghouse"	G	G		
C	1.97	CBS Radio - Epicenter studio	P	n/a		
O	2.25	Hilton Garden Inn	G/F	n/a		
F	2.42	CBS Radio studios	F	F/P		
E	4.10	CBS Radio former studios	G/F	F/P		
K	7.60	Fred Smith residence	G	F		
P	10.40	Fairfield Inn & Suites	P	P		
G	13.03	John Dolive residence	F	P		
H	16.01	Hair Salon	P	n/a		
I	16.62	Alan Lane residence	P	n/a		
Q	18.48	McDonald's	P	n/a		
Q	18.48	McDonald's / B	P	n/a		
L	22.45	Joshua Pierce residence	P	n/a		
M	24.95	Brad Humphries residence	F/P	n/a		
		No service expected				

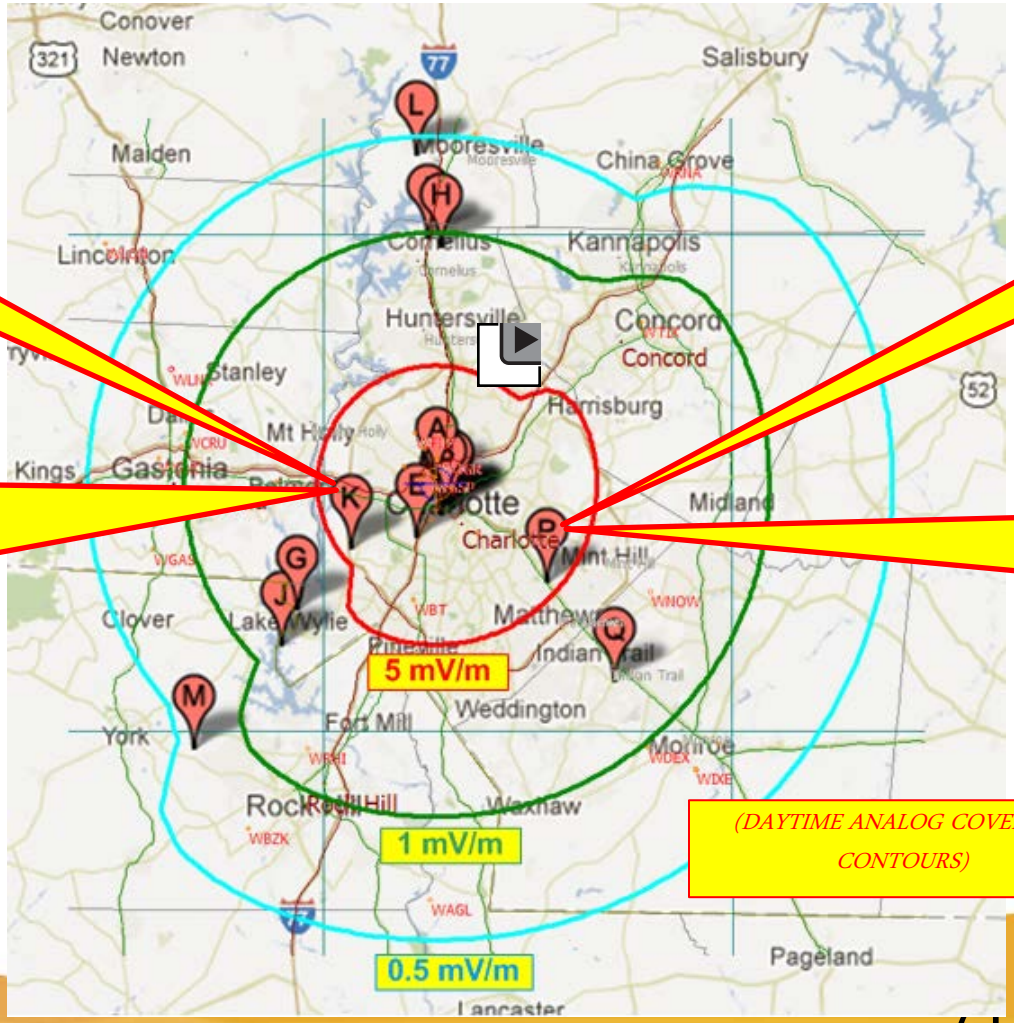
KEY: **G**– Good, **F**– Fair, **P**– Poor, **n/a**– not available

HD Radio®

Indoor test results

Fred Smith residence nighttime analog

Fred Smith residence nighttime all-digital



Fairfield Inn daytime analog

Fairfield Inn daytime all-digital

Summary of PRELIMINARY results

- Daytime – solid all-digital coverage well beyond the 0.5 mV/m analog contour on most test routes
- Nighttime – solid all-digital coverage well beyond the 5 mV/m analog contour
- Indoor – good performance within the 5 mV/m analog contour

Disclaimer

- These are PRELIMINARY results
  - EXPANDED BAND
  - NON-DIRECTIONAL STATION
  - SINGLE-STATION TEST
- Additional data is needed to fully understand the capabilities of all-digital AM IBOC

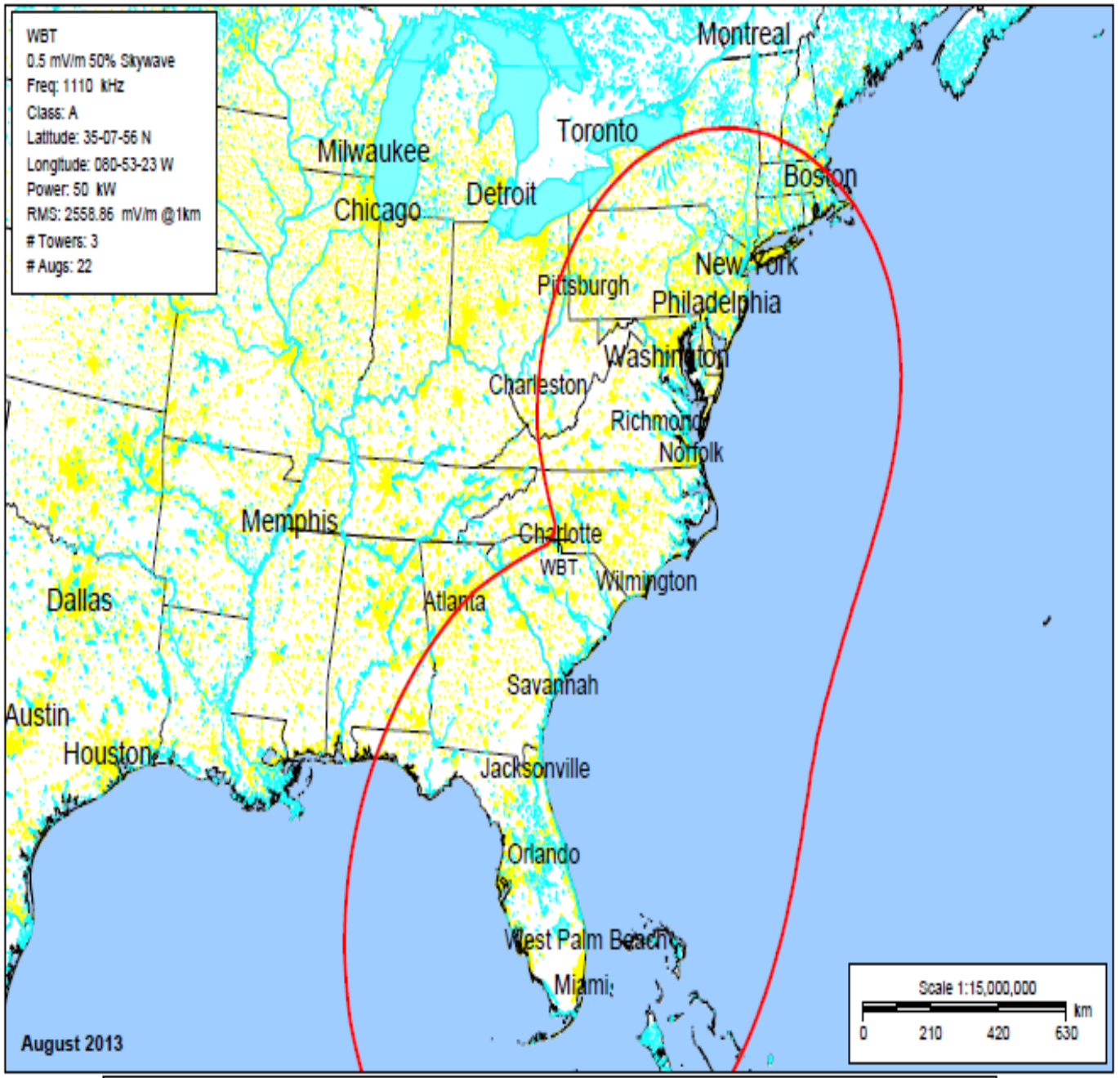
All-digital AM testing, WBT

- WBT remote listening
- All-digital AM receiver behavior

WBT remote listening

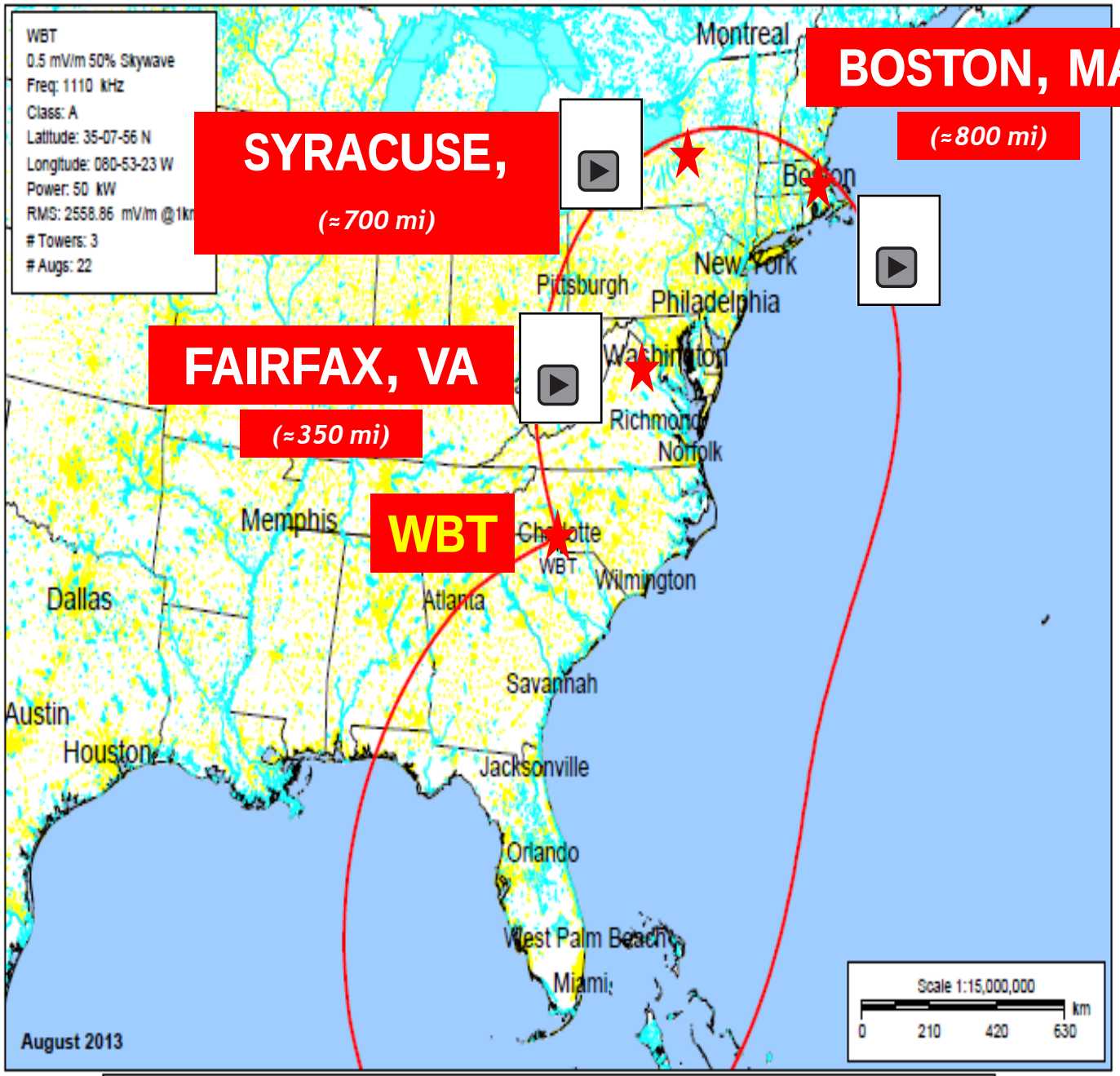
- WBT is a class A “clear channel” station
- All WBT tests were conducted at night, providing opportunity for remote listening
- WBT all-digital AM signal was received from Florida to Massachusetts

WBT
0.5 mV/m
nighttime
50%
skywave
contour



COMPUTED 0.5 mV/m NIGHTTIME 50% SKYWAVE CONTOUR FOR WBT, CHARLOTTE, NORTH CAROLINA

WBT
0.5 mV/m
nighttime
50%
skywave
contour

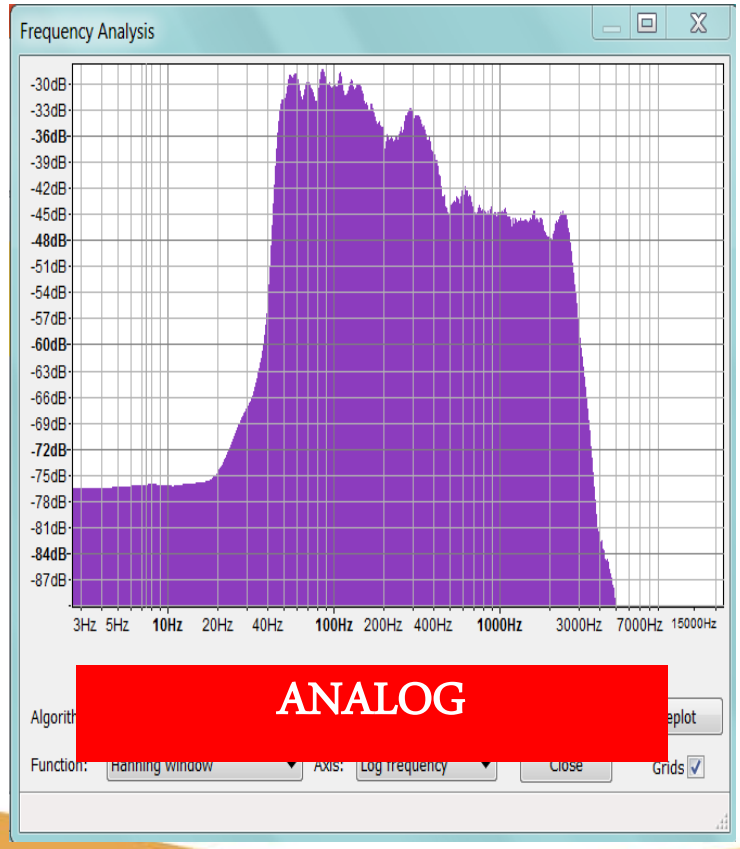


COMPUTED 0.5 mV/m NIGHTTIME 50% SKYWAVE CONTOUR FOR WBT, CHARLOTTE, NORTH CAROLINA

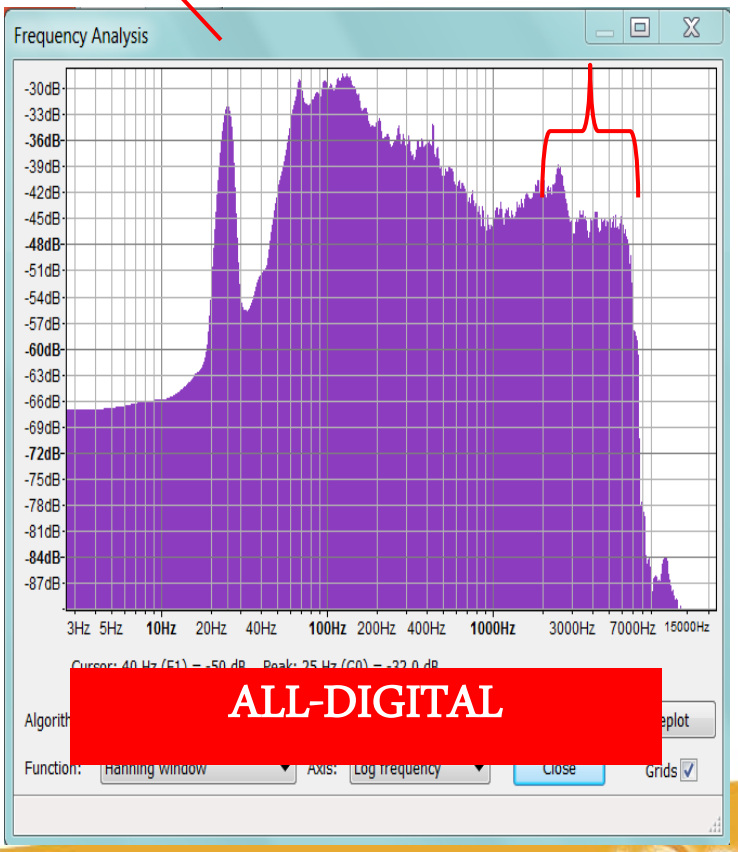
Audio spectrum

25 Hz tone

Extended frequency response



ANALOG



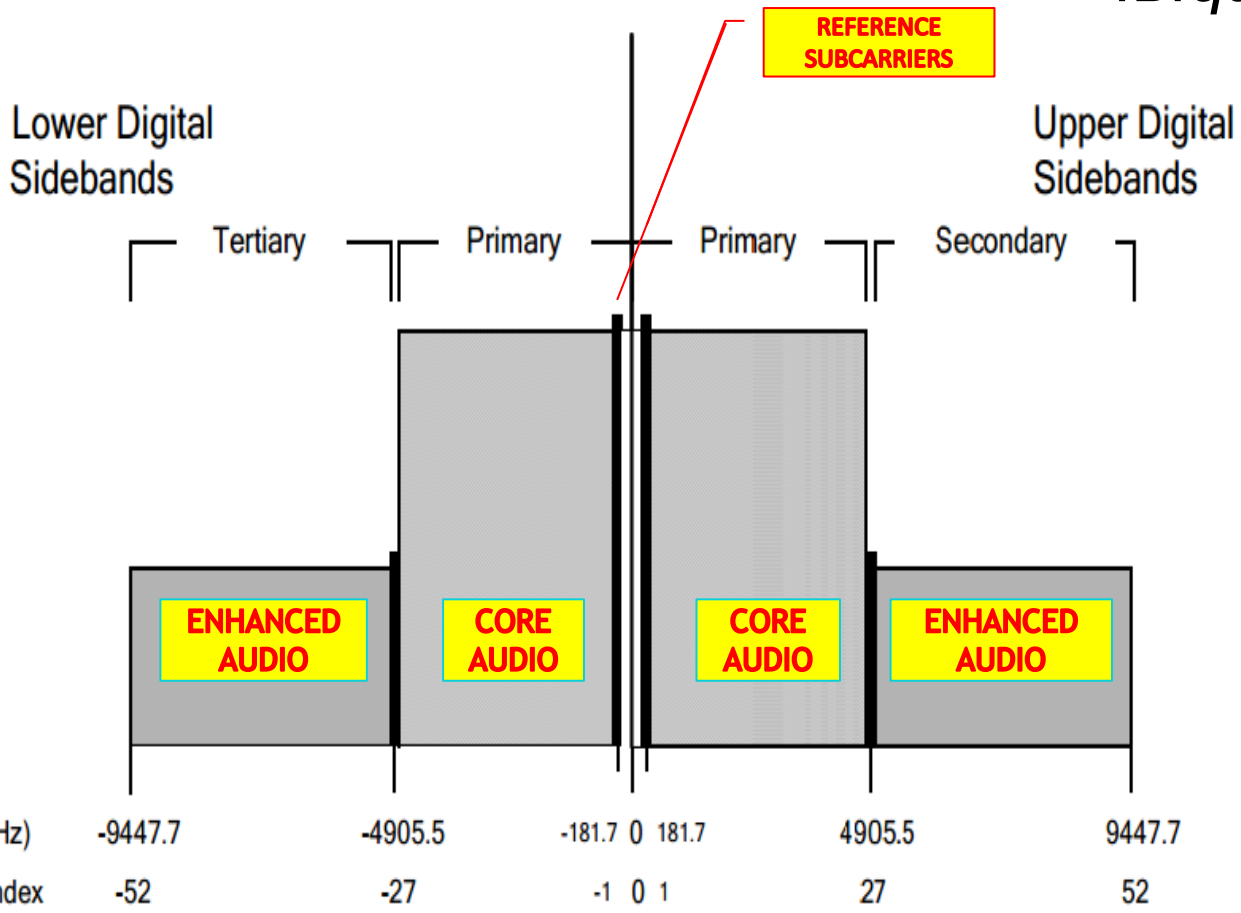
ALL-DIGITAL

All-digital AM receiver behavior

- Hybrid IBOC receivers “blend to analog”
- For all-digital AM, no analog signal present
  - NO “BLEND TO ANALOG”
- Four possible audio states:
  - ENHANCED – MUTING
  - CORE – ANALOG (STATIC)

All-digital signal

SOURCE: iBiquity



Blending information

SOURCE: iBiquity

RECEPTION STATE	SUBCARRIERS PRESENT	AUDIO STATE	COMMENTS
Enhanced & core	-52 to +52 (all)	Enhanced audio	Enhanced audio requires secondary & tertiary subcarriers which are at -30 dBc
Core only	-26 to +26	Core audio	Core audio is on primary subcarriers which are at -15 dBc
Sync only	-1 and +1 (reference subcarriers)	Muting	Ref. subcarriers also at -15 dBc but are BPSK and combined for 15 dB power advantage over primary subcarriers
No OFDM subcarriers		Analog	Audio will be static / interfering signal

Summary

- Thanks to our partners!
- NAB Labs will continue to conduct all-digital AM tests
- Looking for volunteer stations, especially class C stations already converted to hybrid IBOC on these frequencies:
  - 1230 kHz – 1240 kHz – 1340 kHz
  - 1400 kHz – 1450 kHz – 1490 kHz