Field Testing of ATSC 3.0 Physical Layer Technologies

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It Started here in Madison!

- October 2014
- Facilities of WKOW-TV
- Modes Tested
  - Fixed reception
  - Indoor reception
  - Mobile reception
- Middle of the night
  - WKOW; Kohl Center; Steel Garage; Marriott
  - Were you with us??

- Additional Tests in Cleveland – dedicated 24/7 channel
  - May and July 2015
October 22, 2014.....

WKOW-TV
Facilities

Field Testing at Night
October 22, 2014.....

Indoor Tests
Kohl Center
October 22, 2014…..

Indoor Reception in Steel Garage

Ultra HD (4K) at Marriott
5 Key Features of ATSC 3.0

• Robust Mobile Reception
• Ultra HD TV Transmission
• IP Transport
• Advanced Emergency Alerting
• Immersive Audio

America’s TV viewers will benefit from ATSC 3.0, as broadcast television integrate new capabilities and features into the receivers of the future.
Physical Layer – as Field Tested

• OFDM – Based
  – LDPC inner coding
  – Code rates 5/15 to 13/15
  – GI = 30 to 240 uS (60 uS & 120 uS tested)

• “Futureproofing”
  – Preamble Signaling
  – FEF (Future Extension Frames)
  – Carries TS, IP or GS (Generic Stream) packets
Much of LG/Zenith/GatesAir Technology Included in ATSC 3.0 Physical Layer Candidate Standard

**Green element:** first Physical Layer Candidate Standard

**Blue elements:** second Physical Layer Candidate Standard
System Highlights

- OFDM Modulation
- LDPC coding
- 36% capacity increase over ATSC 1.0
- HEVC coding for video
- Multiple Data Pipes
Spectrum Efficiency vs. SNR

26.4 Mbps @ 15 dB
(36% increase over A/53)

A/153 ¼ Rate

32k-FFT, GI-1/160, P128_2
FUTURECAST Features

• Multiple Pipes with Varying Robustness
• Hierarchical signaling structure
• FIC for fast channel change
• EAC Emergency Alert Channel
• Frame Repetition Unit (FRU) for robust signaling
  – Hierarchical Frame structure adopted in ATSC 3.0 Candidate Standard as Frames and Subframes with multiple Physical Layer Pipes (PLPs)
Simulations; then Hardware

• Simulations identified inconsistencies
  Corrected before hardware built

• FPGA Modulator

• FPGA Receivers
  – Identified Sensitivity Implementation loss (> 1 dB)
  – Hardware modified prior to field testing
Three Transmission Modes

- DP0 High Capacity Mode
  - 36% higher than VSB
- DP1 Similar Threshold to ATSC M/H ¼ Rate
  - 2 ½ times the data capacity of M/H
- DP2 Very Robust Deep Penetration
Mobile Reception in Madison

• Mobile Routes
  – 53 miles Southwest
  – 40 miles Northwest (past ridge)
  – Downtown
• Over 16,500 data points for each mode
• DP0 mobile performance was poor (expected)
• M/H and DP1 performance was similar
Madison Mobile Routes
Errors over-reported
System Improvements Based on Madison Tests

• Error reporting issue identified
• DP2 performance enhanced with improved preamble
Transmitter Availability

• Madison
  – 1:00 AM to 4:00 AM in place of regular programming

• Cleveland
  – 24/7 access to spare transmitter tied up in channel allocation freeze

• Mobile routes measured VSB/MDTV in one direction and FUTURECAST in the return direction
Mobile Reception in Cleveland

• Mobile Routes
  – 50 miles Southwest
  – 40 miles East
  – 25 miles South
  – Downtown
  – Southern Edge of Reception

• Over 18,000 data points for each mode

• DP2 Performance Improvement Verification
Cleveland Reception – Radials (May)
Cleveland Reception – Fringe (July)
Fixed Reception Threshold
Fixed Reception Comparison

• DP0 & VSB have similar thresholds and similar performance

• DP1 & MH at similar thresholds have similar performance

• Channel Impairment loss has greater impact at higher thresholds
Basement Reception in Cleveland

• DP2 Reception where no TV signal has gone before

• Cell phone operation “iffy”
Basement Reception
Field Test Summary

• FPGA implementations provided extremely helpful data capture of key performance values
• Three simultaneous transmission modes
  – DP0: Similar threshold to VSB with improved capacity
  – DP1: Similar threshold to M/H ¼-rate with 2 ½ x efficiency (in bits/Hz)
  – DP2: Deeper indoor penetration than M/H
• RF recordings captured to assist in further lab development
Conclusion

• FUTURECAST hardware tests verify performance of technologies for ATSC 3.0, and have helped discover areas for refinement
• Increased capacity over VSB (ATSC 1.0) at similar thresholds is confirmed
• Much lower thresholds than ATSC 1.0 are possible
• Direct comparison to ATSC 1.0 demonstrates that performance is primarily dependent on white noise threshold – no unforeseen problems with new modulation / coding
Conclusion (2)

- FUTURECAST Tests Demonstrate Benefits of ATSC 3.0 Technologies
- Greatly improved bit-rate capacity for the same threshold as today’s ATSC system
- Same coverage area for the same threshold
- Usable thresholds below existing M/H performance
- More mode flexibility
  - Improved indoor reception
  - Mobile modes
  - Handheld modes
- ATSC 3.0 should exhibit performance and benefits comparable to FUTURECAST
Thank You and Q & A