Implications and Optimization of Coverage and Payload for ATSC 3.0

April 23, 2017
NAB Show 2017

Featuring GatesAir’s

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As media, entertainment and technology converge, the result is a connected network that is redefining business models and revenue streams.
Implications and Optimization of Coverage and Payload

Outline

• ATSC 1.0 Parameters review
• ATSC 3.0 Parameters review
• ATSC 1.0 vs ATSC 3.0 Coverage
• Payload vs Coverage
• Data vs SNR (Signal-to-Noise Ratio)
• Indoor Coverage (high data rates)
• ATSC 3.0 Multiple Physical layer Pipes
• SFN (Single Frequency Networks)
• Summary
ATSC 1.0 (8VSB Modulation)

ATSC 1.0 coverage was based on the following variables:

• Antenna Height above average terrain
• Antenna Gain
• Length and size for the Transmission line (Losses)
• RF System (Losses)
• Transmitter Power Output
• Data rate 19.39 Mbit/s
• Signal-to-noise ratio 15.2dB
ATSC 3.0 (OFDM Modulation)

ATSC 3.0 coverage is still based on the following variables:

• Antenna Height above average terrain
• Antenna Gain
• Length and size for the Transmission line (Losses)
• RF System (Losses)
• Transmitter Power Output
• Data rate 0.83 to 57.0 Mbit/s (dependent on modulation Parameters)
• Signal-to-noise ratio -5.5dB to 36.5dB (dependent on modulation Parameters)
ATSC 3.0 (OFDM Modulation)

ATSC 3.0 modulation variables that effect data rate:
• QPSK, 16 QAM, 64 QAM, 256 QAM, 1024 QAM & 4096 QAM

Low Density Parity Check (LDPC) Forward Error Correction (FEC), inner coding:
• Length: 16200 Bits or 64800 Bits

Fast Four Transform (FFT size)
• 8k, 16k & 32k
ATSC 3.0 (OFDM Modulation)

Guard Interval
• 27.7 usec, 55.5 usec, 74.07 usec, 111.11 usec, 148.1 usec, 222.2 usec, 296.3 usec, 351.9 usec, 444.4 usec, 527.8 usec, & 592.6 usec

Bose, Chaudhuri, Hocquenghem (BCH) outer coding:
• On or Off

Scattered Pilots:
• Time (2 or 4) & Density (normal or dense)

Frame Duration:
• 100 ms, 150 ms, 200 ms, & 250 ms
ATSC 3.0 (OFDM Modulation)

Higher the data Rate the less Robust the Signal

Lower the data Rate the more robust the signal
The signal-to-noise ratio (SNR) and the data rate have a direct relationship to the distance the ATSC 3.0 signal can be received. The lower the signal-to-noise ratio (SNR) the further away from the transmission source the signal can be received. The higher the signal-to-noise ratio the less distance from the transmission source the signal be received.
ATSC 1.0 AND ATSC 3.0 COMPARISON

Parameters for Comparison

- ITU 1812-4 propagation model
- The Map area used has an area of 85478 km²
- The coverage area % is determined based on the set map area
- ATSC 1.0 has a bit rate of 19.39 Mbit/s at a signal-to-noise ratio of 15.2db
- ATSC 3.0 parameters were set to provide 19.5 Mbit/s at a signal-to-noise ratio 11.5db
- The antenna gain, height of the tower, the transmission line and transmitter TPO were kept same for both ATSC 1.0 & ATSC 3.0
ATSC 1.0 AND ATSC 3.0 COMPARISON

Parameters for Comparison

- Transmitter Power out: 36.4kW pre-filter
- Transmit antenna gain: 13.0dBi
- Antenna type: Omni directional slot
- Antenna mount: Top Mounted
- Antenna beam tilt: -1.25°
- Antenna null fill: 20%
- Antenna Height above ground level: 1023.4ft
- Line type: 6-1/8” 50 Ohm Rigid line
- Line losses: -1.32dB
- Mask filter and RF system losses: -.30dB
- Effective radiated power: **500kW**
ATSC 1.0 AND ATSC 3.0 COMPARISON

ATSC 1.0
Calculated Coverage:
41dBuV/m FCC contour
Receive antenna Height: 10m
Receive antenna Gain: 10dB
Transmit Channel: 25
Channel bandwidth: 6MHz
SNR: 15.2dB (19.39Mbit/s)
Map Area: 85478 km²
Gaussian Channel (AWGN)

41.7% of the Total Map Area
ATSC 1.0 and ATSC 3.0 Comparison

ATSC 3.0
- Calculated Coverage: 41dBuV/m FCC contour
- Receive antenna Height: 10m
- Receive antenna Gain: 10dB
- Transmit Channel: 25
- Channel bandwidth: 6MHz
- SNR: 11.5dB (19.5Mbit/s)
- Map Area: 85478 km²
- Gaussian Channel (AWGN)

47.8% of the Total Map Area
6.1% increase in coverage compared to ATSC 1.0
ATSC 3.0 Payload vs Coverage

- **QAM**: QPSK Data Rate: 6.5Mbit/s
- Signal-to-Noise Ratio (SNR): 1.97dB
- Low density parity check Length: 64800 bits
- Low density parity check code rate: 9/15
- Bose, Chaudhuri, Hocquenghem (BCH): On
- Fast Fourier transform (FFT): 32K
- Guard interval: 222.22 usec
- Scatter Pilots density: normal
- Scatter Pilots (time) spacing: normal
- Frame duration 200ms
ATSC 3.0 PAYLOAD VS COVERAGE

ATSC 3.0 Calculated Coverage:

- **QPSK**
- 41dBuV/m FCC contour
- Receive antenna Height: 10m
- Receive antenna Gain: 10dB
- Transmit Channel: 25
- Channel bandwidth: 6MHz
- SNR: 1.97dB (6.5Mbit/s)
- Map Area: 85478 km²
- Gaussian Channel (AWGN)

60% of the Total Map Area
ATSC 3.0 ATSC 3.0 PAYLOAD VS COVERAGE

- **QAM: 16 QAM** Data Rate: 13 Mbit/s
- Signal-to-Noise Ratio (SNR): 7.32dB
- Low density parity check Length: 64800 bits
- Low density parity check code rate: 9/15
- Bose, Chaudhuri, Hocquenghem (BCH): On
- Fast Fourier transform (FFT): 32K
- Guard interval: 222.22 usec
- Scatter Pilots density: normal
- Scatter Pilots (time) spacing: normal
- Frame duration 200ms
ATSC 3.0 Calculated Coverage: **16 QAM**

41dBuV/m FCC contour
Receive antenna Height: 10m
Receive antenna Gain: 10dB
Transmit Channel: 25
Channel bandwidth: 6MHz
SNR: 7.32dB (13 Mbit/s)
Map Area: 85478 km2
Gaussian Channel (AWGN)

53.7% of the Total Map Area
ATSC 3.0 PAYLOAD VS COVERAGE

ATSC 3.0 Calculated Coverage:
64 QAM
41dBuV/m FCC contour
Receive antenna Height: 10m
Receive antenna Gain: 10dB
Transmit Channel: 25
Channel bandwidth: 6MHz
SNR: 11.55dB (19.5 Mbit/s)
Map Area: 85478 km²
Gaussian Channel (AWGN)

47.8% of the Total Map Area
**ATSC 3.0 PAYLOAD VS COVERAGE**

**ATSC 3.0 Calculated Coverage:**

**256 QAM**  
41dBuV/m FCC contour  
Receive antenna Height: 10m  
Receive antenna Gain: 10dB  
Transmit Channel: 25  
Channel bandwidth: 6MHz  
SNR: 15.55dB (26 Mbit/s)  
Map Area: 85478 km2  
Gaussian Channel (AWGN)  

42.9% of the Total Map Area
ATSC 3.0 PAYLOAD VS COVERAGE

ATSC 3.0 Calculated Coverage: **1024 QAM**
41dBuV/m FCC contour
Receive antenna Height: 10m
Receive antenna Gain: 10dB
Transmit Channel: 25
Channel bandwidth: 6MHz
SNR: 19.45dB (32.5 Mbit/s)
Map Area: 85478 km2
Gaussian Channel (AWGN)

39.2% of the Total Map Area
ATSC 3.0 PAYLOAD VS COVERAGE

ATSC 3.0 Calculated Coverage:

**4096 QAM**
41dBuV/m FCC contour
Receive antenna Height: 10m
Receive antenna Gain: 10dB
Transmit Channel: 25
Channel bandwidth: 6MHz
SNR: 23.05dB (39.0 Mbit/s)
Map Area: 85478 km2
Gaussian Channel (AWGN)

34.7% of the Total Map Area
ATSC 3.0 Payload vs Coverage

From 16QAM to 4096QAM = ~19% difference in coverage
From 64QAM to 4096QAM = ~13.1% difference in coverage
From QPSK to 4096QAM = ~25.3% difference in coverage
When using the Rayleigh channel model, the signal-to-noise ratio (SNR) is higher due to the addition of multipath reception and non-directional receive antenna. The Rayleigh channel model SNR is a more realistic customer reception.

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<th>LDPC Length</th>
<th>LDPC Code Rate</th>
<th>AWGN SNR (dB)</th>
<th>Rayleigh SNR (dB)</th>
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<td>36.54</td>
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<td>36.54</td>
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ATSC 3.0 Indoor Coverage

Additional challenges:
- Losses due to building penetration (~-11dB)
- Man-made noise (~-2dB)
- Changes in receive antenna gain (~-10dB)
- Receive antenna height reduction (~-12dB)

Additional losses: ~-30dB to -35dB

SNR: 23.05dB, 4096 QAM
Map Area: 85478 km²
Gaussian Channel (AWGN)

Maximum coverage area is calculated to be 7.4% of the total map area.
The use of multiple physical layer pipe lines (PLP) allows the broadcaster to tailor the data or programs to specific data allocations or coverage. Tailoring each pipe line to different parameters allows for additional coverage by changing the data rate for specific targeted viewers.
ATSC 3.0 SFN (SINGLE FREQUENCY NETWORK)

Indoor Coverage 7.4%
500kW ERP Main

Indoor Coverage 8.1%
500kW ERP Main & (4) 15kW ERP SFN Gap fillers

SFN Gap fillers power & height (25m) is reduced so not to exceed the 41dBuv/m Main FCC contour

SFN can be used to increase coverage in a specific locations helping tailor the coverage to high population areas or adding additional coverage to areas with terrain obstructions.
Implications and Optimization of Coverage and Payload

Summary:

The signal-to-noise ratio (SNR) and the data rate have a direct relationship to the distance the ATSC 3.0 signal can be received. The lower the signal-to-noise ratio (SNR) the further away from the transmission source the signal can be received. The higher the signal-to-noise ratio the less distance from the transmission source the signal be received.

Questions?