Implications and Optimization of Coverage and Payload for ATSC 3.0

April 23, 2017

NAB Show 2017

Featuring GatesAir's

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Implications and Optimization of Coverage and Payload

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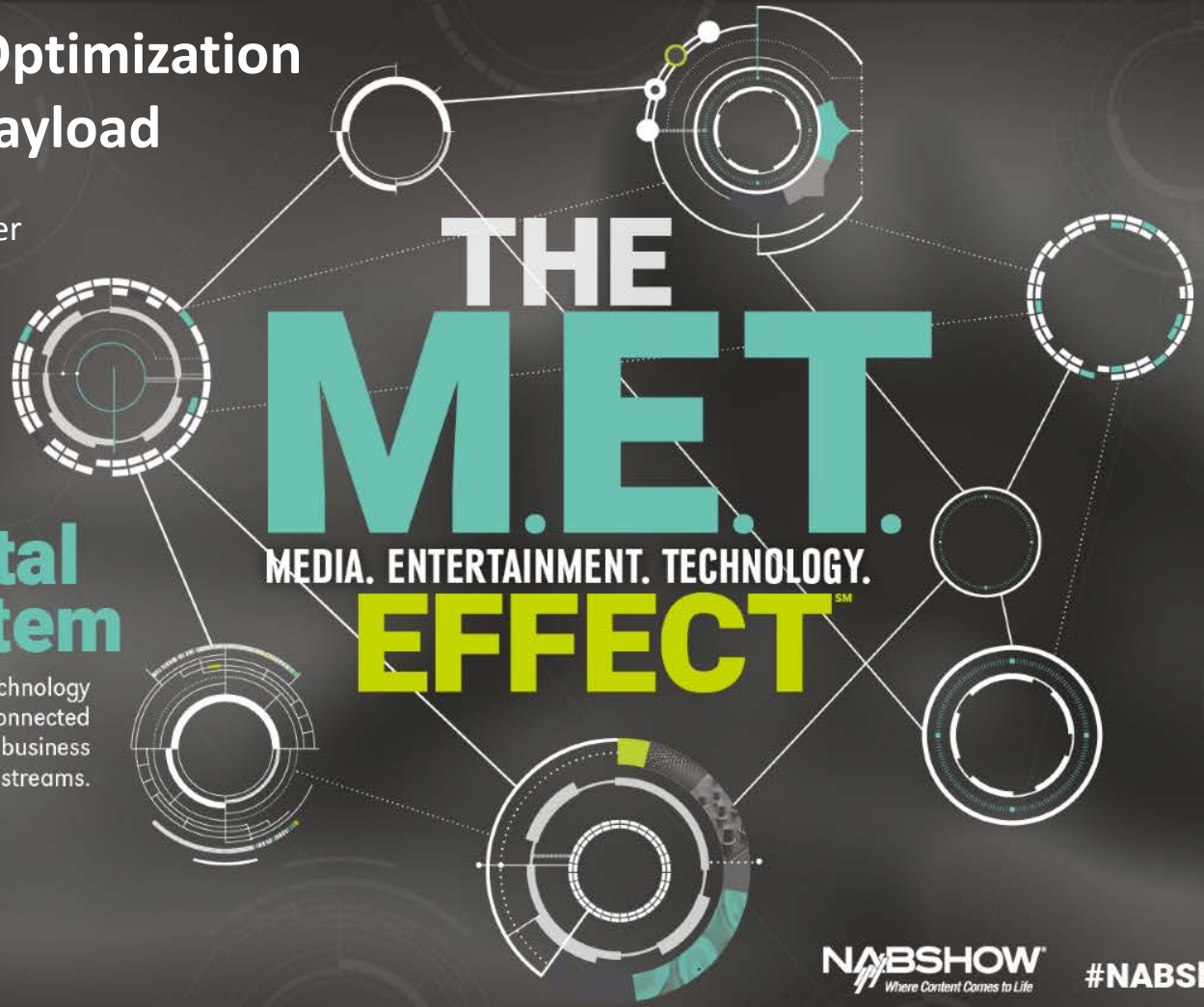


Implications and Optimization of Coverage and Payload

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
- Code Rates: 2/15, 3/15, 4/15, 5/15, 6/15, 7/15, 8/15, 9/15, 10/15, 11/15, 12/15, and 13/15

Fast Four Transform (FFT size)

- 8k, 16k & 32k

ATSC 3.0 (OFDM Modulation)

Guard Interval

- 27.7usec, 55.5usec, 74.07usec, 111.11usec, 148.1usec, 222.2usec, 296.3usec, 351.9usec, 444.4usec, 527.8usec, & 592.6usec

Bose, Chaudhuri, Hocquenghem (BCH) outer coding:

- On or Off

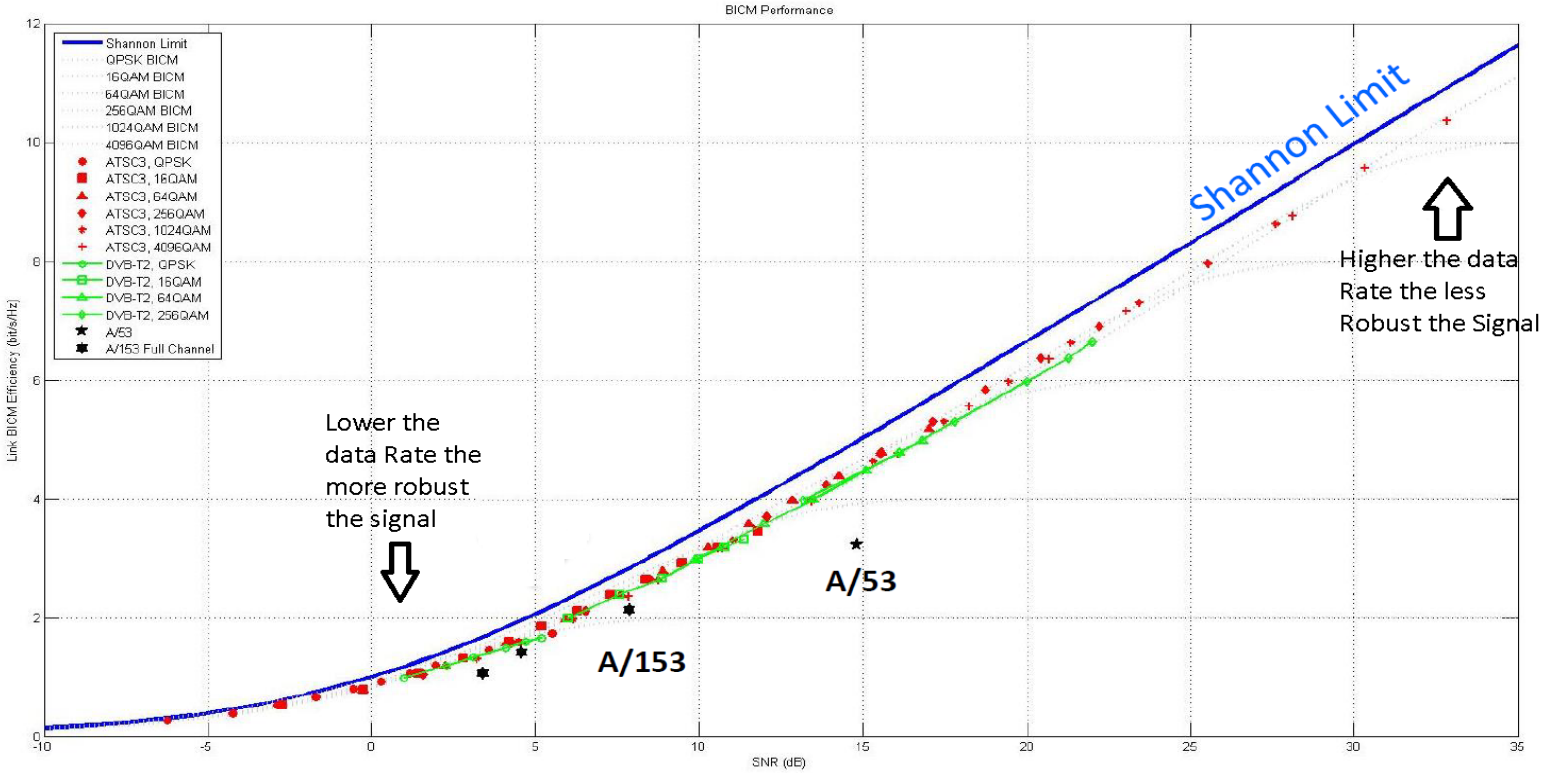
Scattered Pilots:

- Time (2 or 4) & Density (normal or dense)

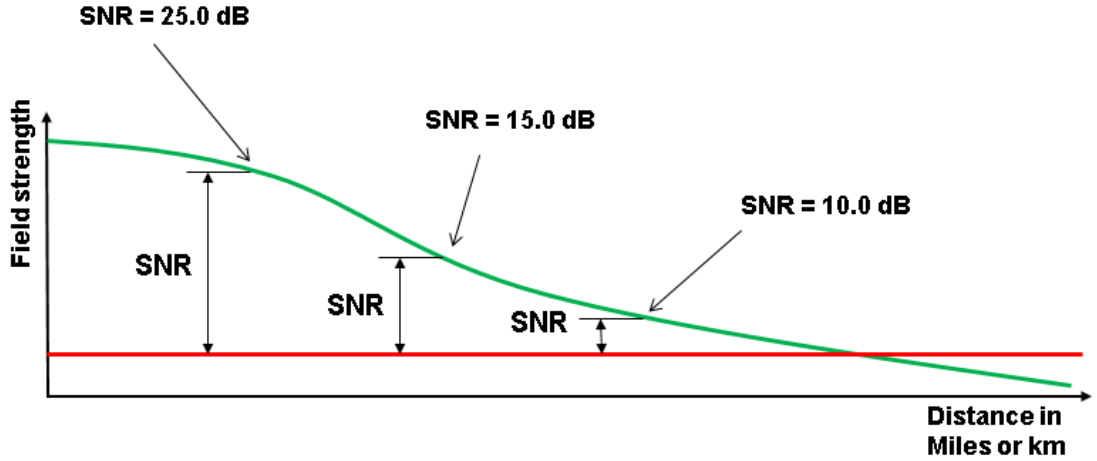
Frame Duration:

- 100ms, 150ms, 200ms, & 250ms

ATSC 3.0 (OFDM Modulation)



ATSC 3.0 (OFDM Modulation)



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

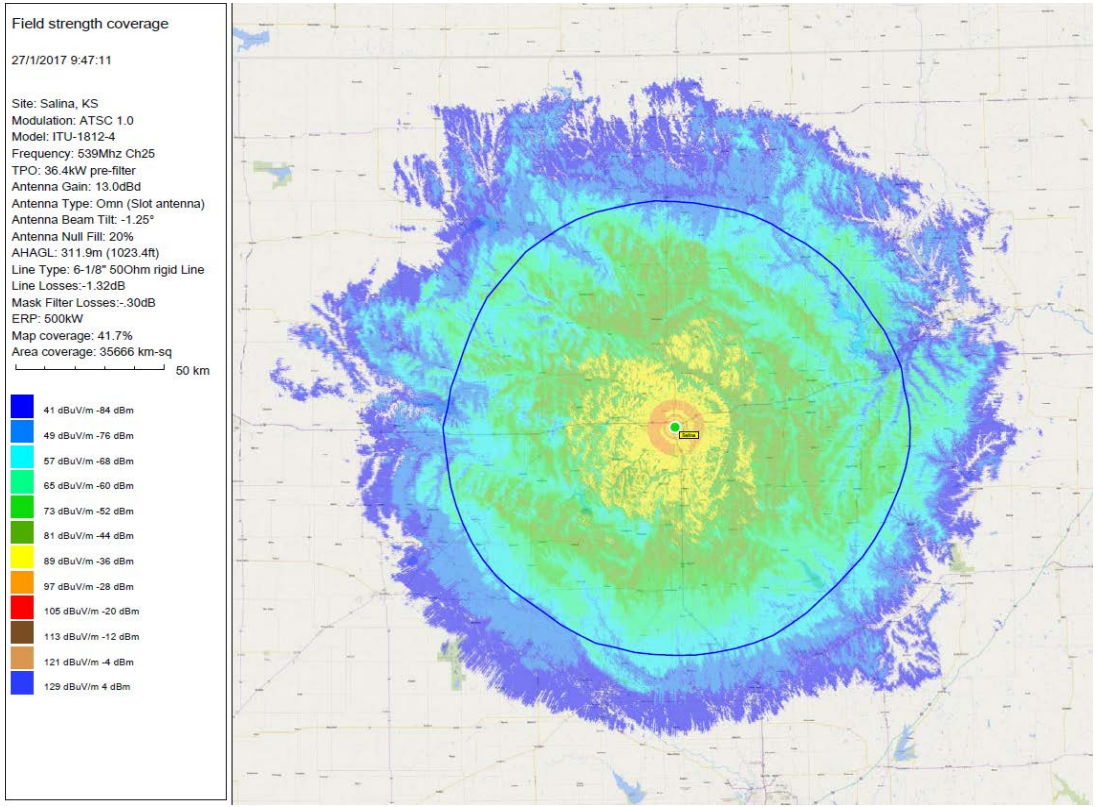
- ITU 1812-4 propagation model
- The Map area used has an area of 85478 km2
- The coverage area % is determined based on the set map area
- ATSC 1.0 has a bit rate of **19.39 Mbit/s** at a signal-to-noise ratio of **15.2db**
- ATSC 3.0 parameters were set to provide **19.5 Mbit/s** at a signal-to-noise 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: 13.0dBd
- 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**

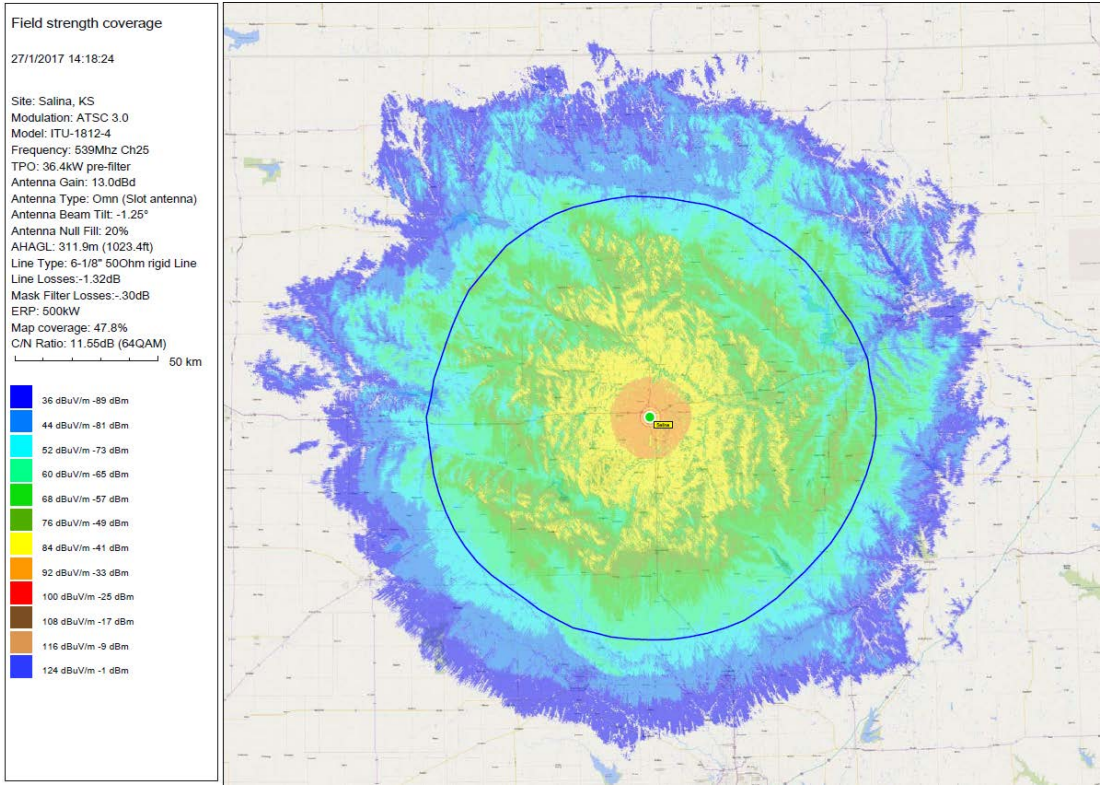
ATSC 1.0 AND ATSC 3.0 COMPARISON



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



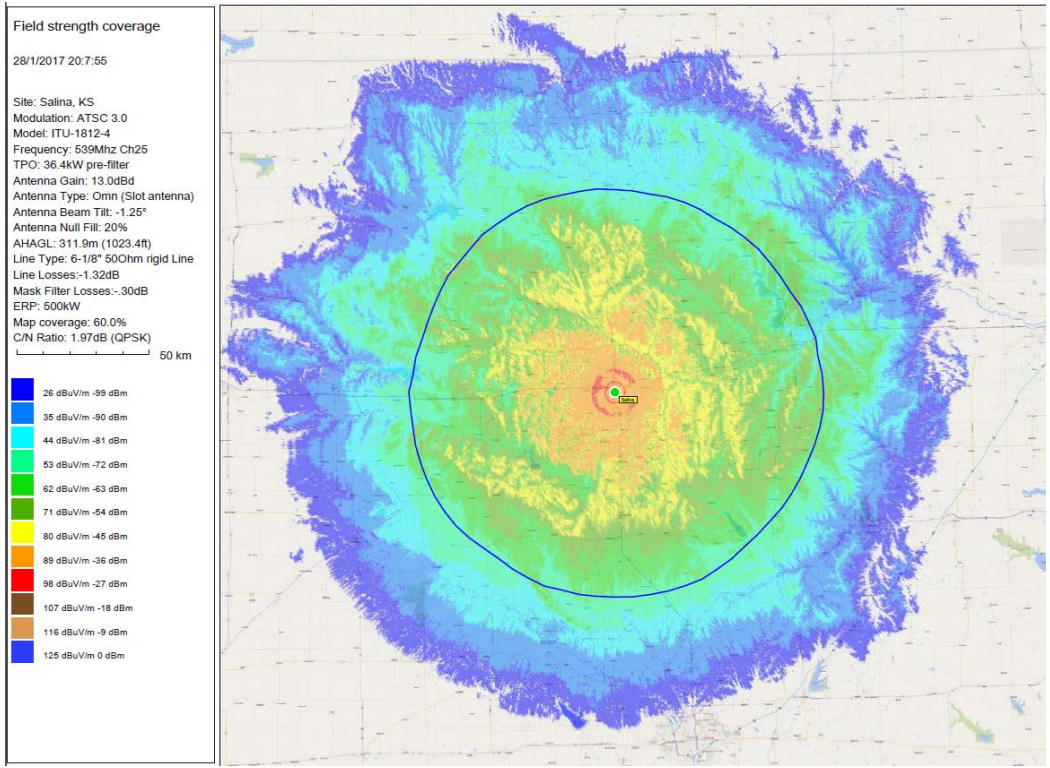
ATSC 3.0 Calculated Coverage:
41dBuV/m FCC contour
Receive antenna Height: 10m
Receive antenna Gain: 10dB
Transmit Channel: 25
Channel bandwidth: 6MHz
SNR: 11.5dB (19.5Mbit/s)
Map Area: 85478 km2
Gaussian Channel (AWGN)

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

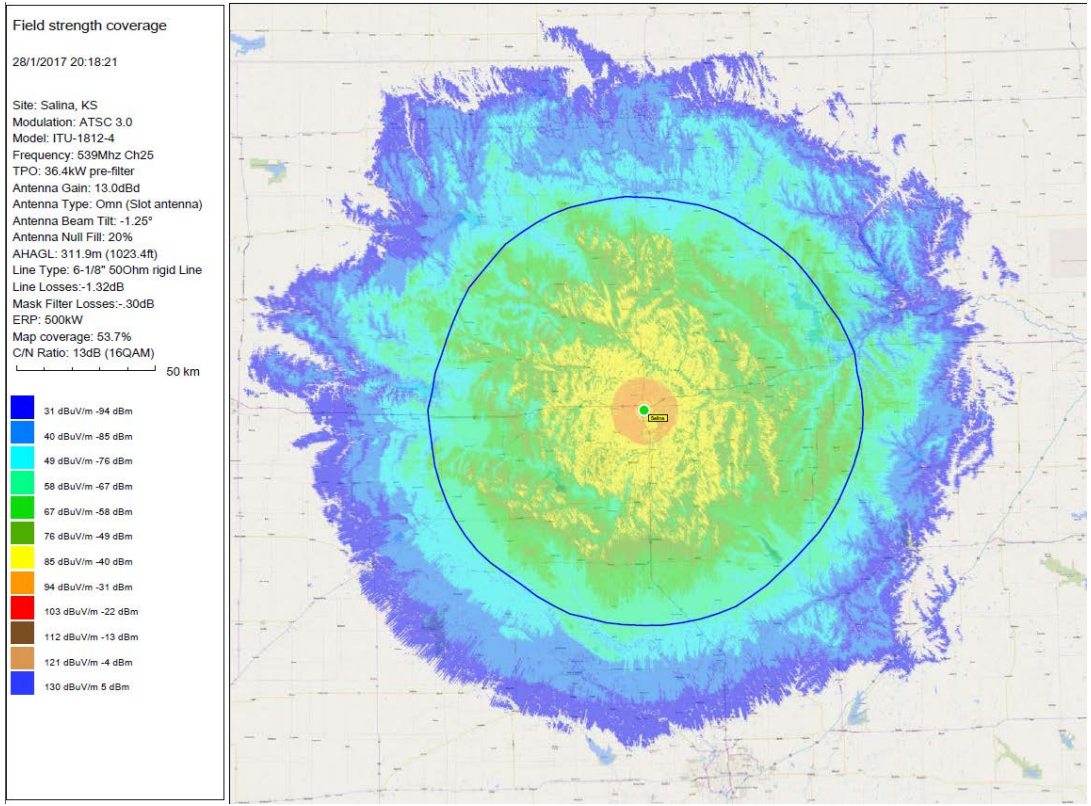
Gaussian Channel (AWGN)

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 Payload vs Coverage



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

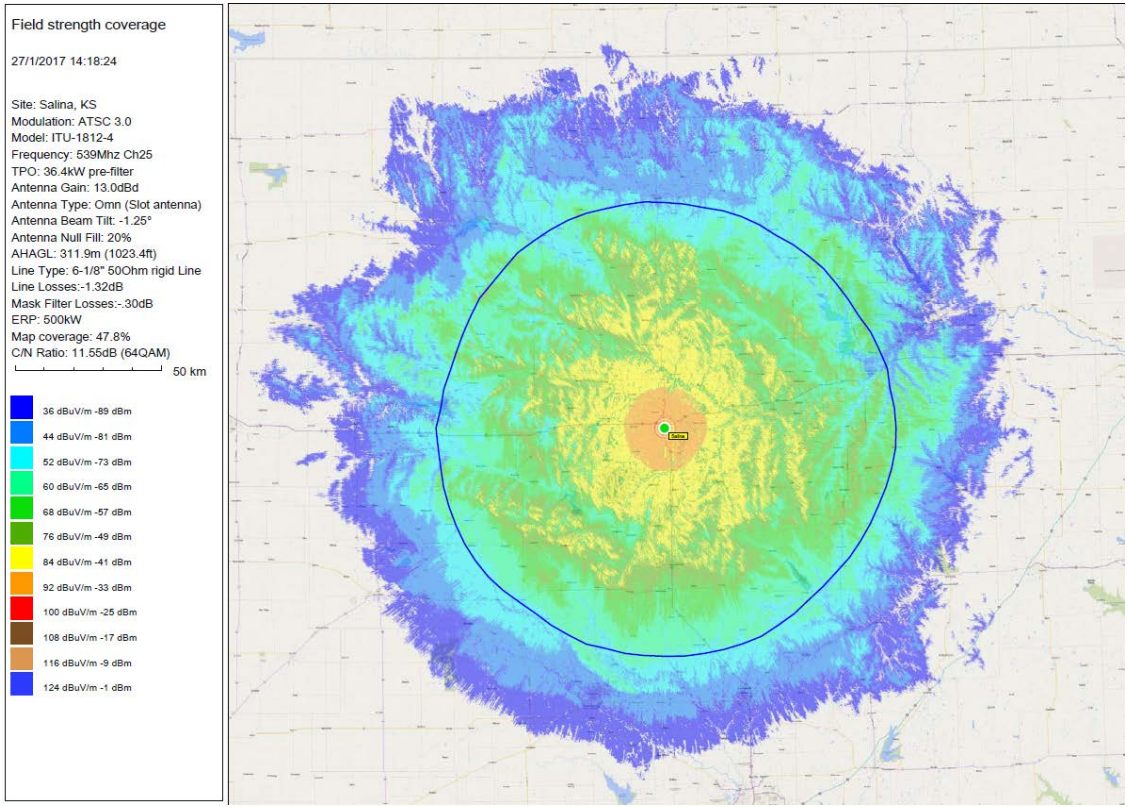
SNR: 7.32dB (13 Mbit/s)

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

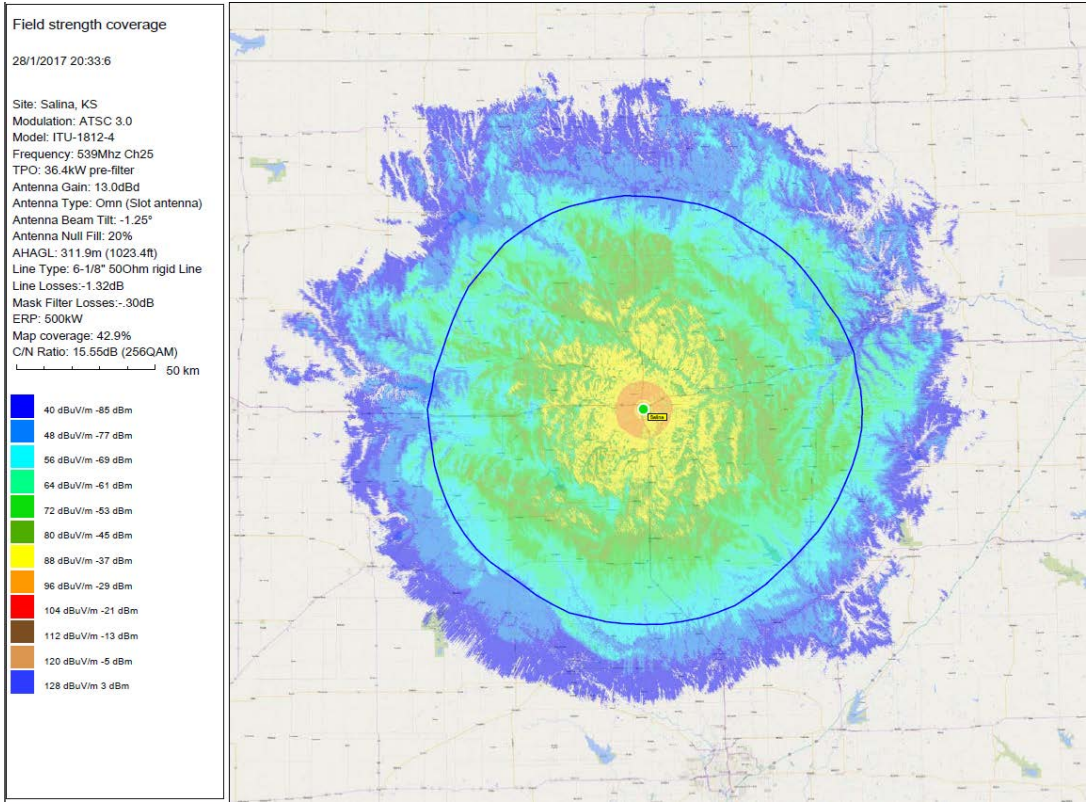
SNR: 11.55dB (19.5 Mbit/s)

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

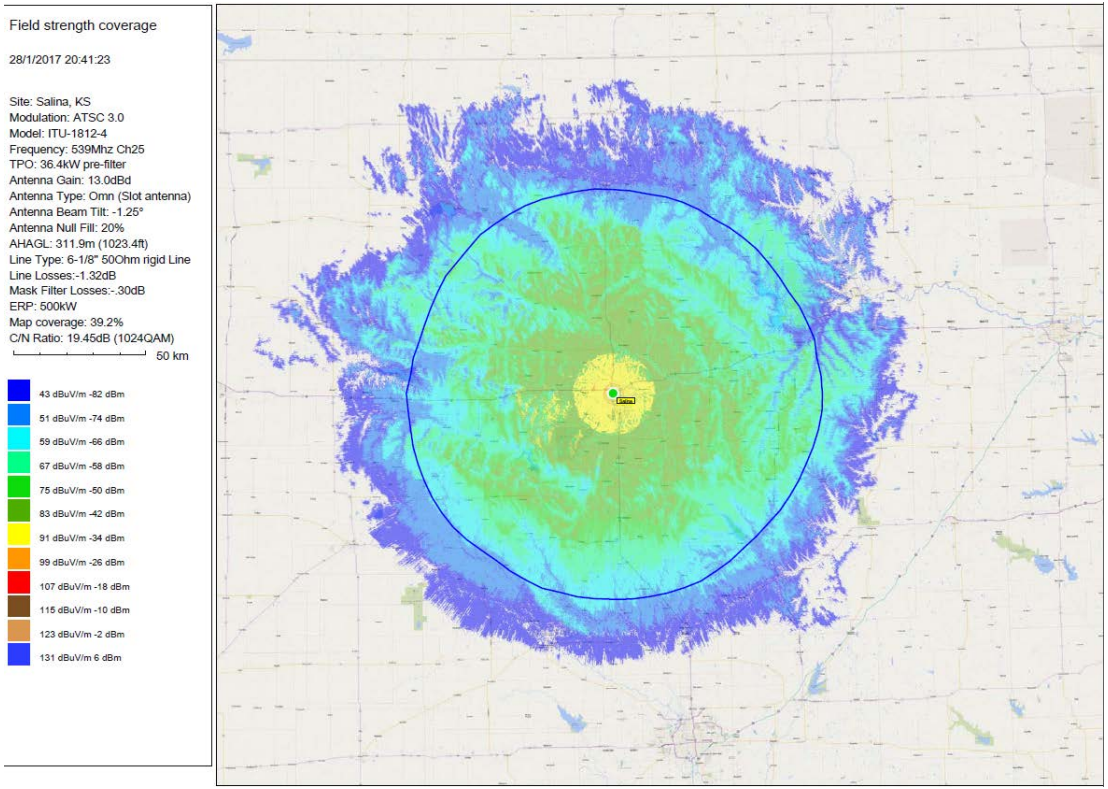
SNR: 15.55dB (26 Mbit/s)

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

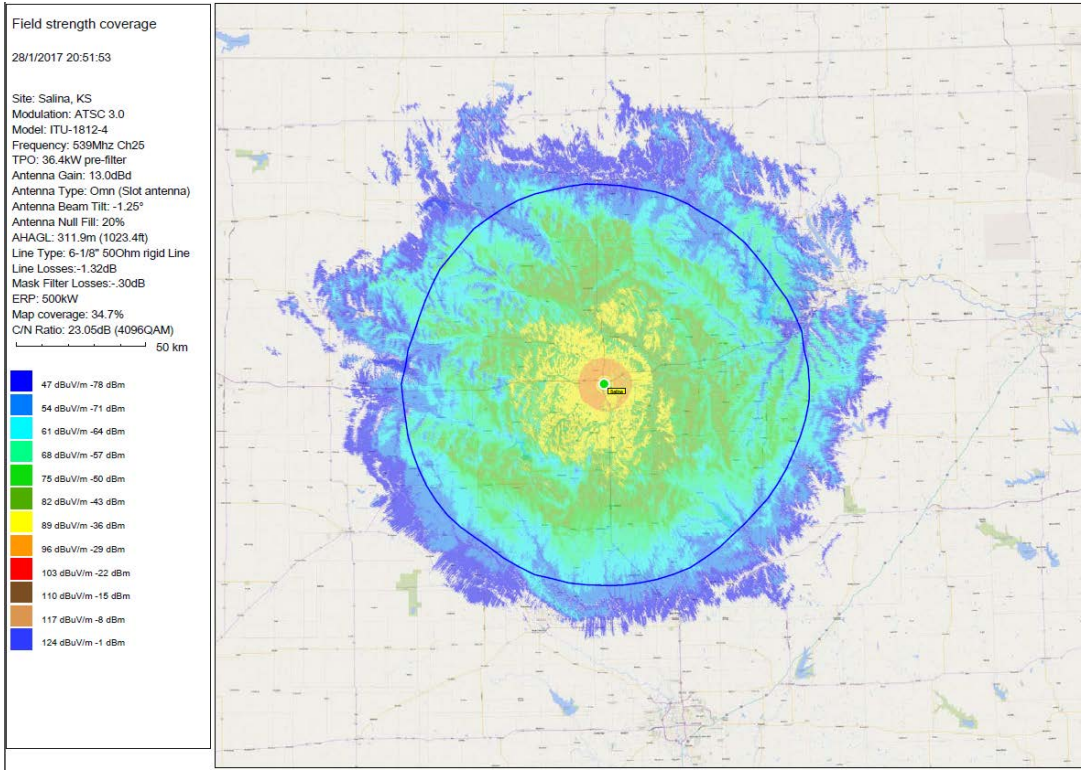
SNR: 19.45dB (32.5 Mbit/s)

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

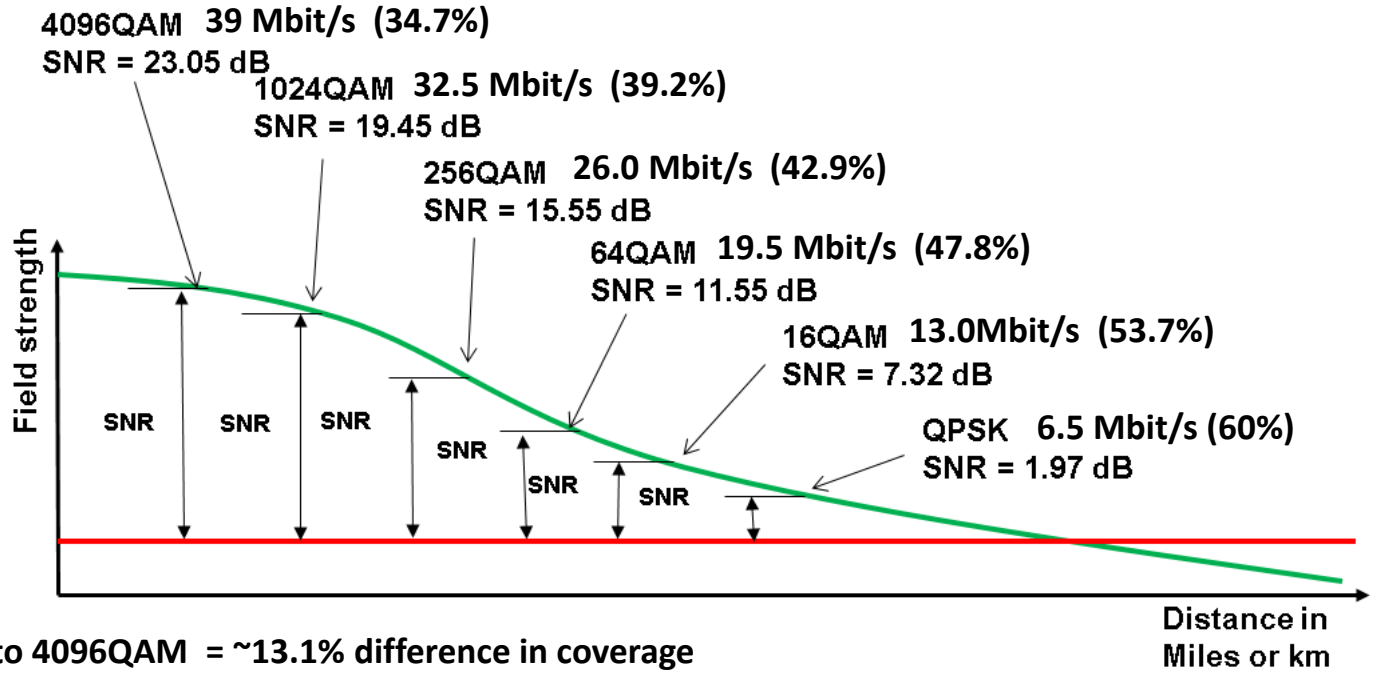
SNR: 23.05dB (39.0 Mbit/s)

Map Area: 85478 km2

Gaussian Channel (AWGN)

34.7% of the Total Map Area

ATSC 3.0 PAYLOAD VS COVERAGE



From 64QAM to 4096QAM = ~13.1% difference in coverage

From 16QAM to 4096QAM = ~19% difference in coverage

From QPSK to 4096QAM = ~25.3% difference in coverage

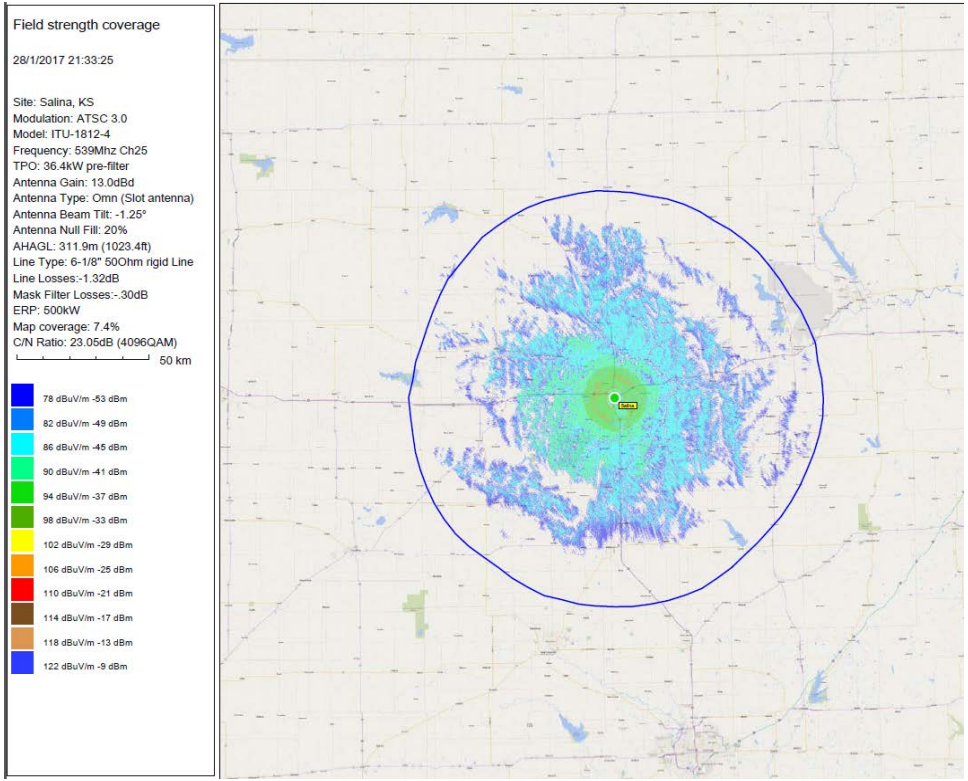
ATSC 3.0 DATA VS SNR

ATSC 3.0 Signal to Noise Ratio (SNR)			BCH (On)		BCH (Off)	
QAM	LDPC Length	LDPC Code Rate	AWGN SNR (dB)	Rayleigh SNR (dB)	AWGN SNR	Rayleigh SNR
1024 QAM	64800	2/15	3.23	4.65	3.23	4.65
		3/15	6.17	8.04	6.17	8.04
		4/15	8.77	10.85	8.77	10.85
		5/15	11.07	13.25	11.08	13.25
		6/15	13.46	15.91	13.39	15.94
		7/15	15.30	17.84	15.30	17.84
		8/15	17.46	20.13	17.49	20.15
		9/15	19.45	22.34	19.47	22.35
		10/15	21.35	24.47	21.37	24.47
		11/15	23.43	26.61	23.43	26.61
		12/15	25.52	28.82	25.52	28.82
		13/15	27.62	31.59	27.62	31.59
4096 QAM	64800	2/15	4.58	6.23	4.58	6.23
		3/15	7.85	9.83	7.85	9.83
		4/15	10.73	12.95	10.73	12.95
		5/15	13.45	15.75	13.45	15.75
		6/15	16.04	18.79	16.06	18.83
		7/15	18.22	21.03	18.22	21.03
		8/15	20.69	23.67	20.71	23.68
		9/15	23.05	26.37	23.08	26.39
		10/15	25.55	28.64	25.57	28.68
		11/15	28.11	31.18	28.12	31.19
		12/15	30.34	33.82	30.34	33.82
		13/15	32.83	36.54	32.84	36.54

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.

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)

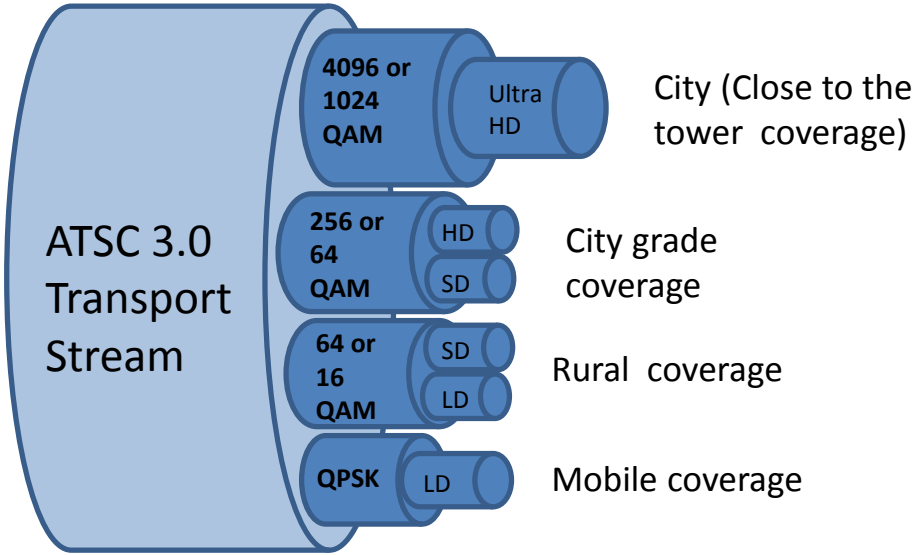
Additional losses : ~-30dB to -35dB

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

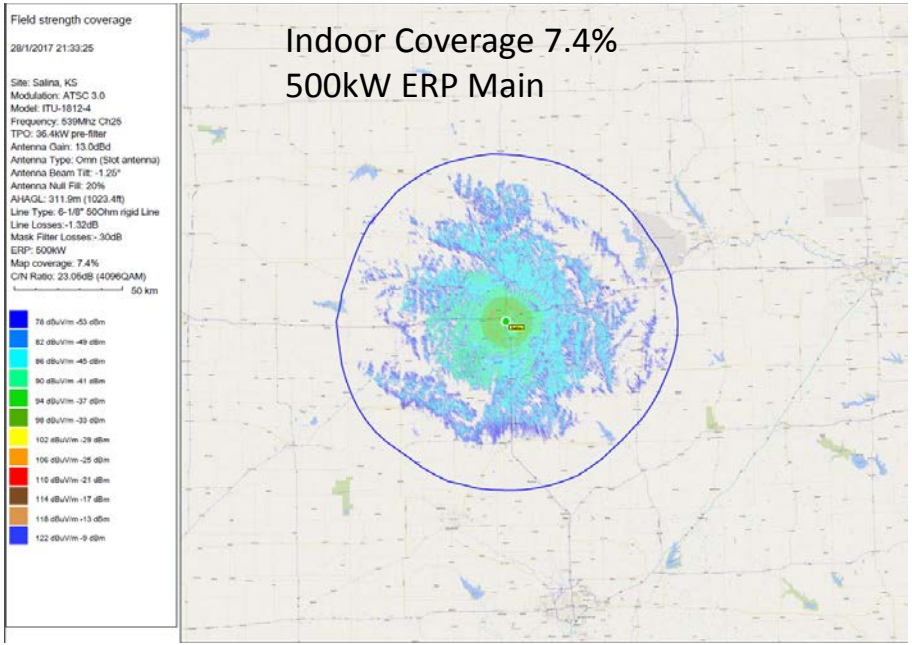
Maximum coverage area is calculated to be 7.4% of the total map area.

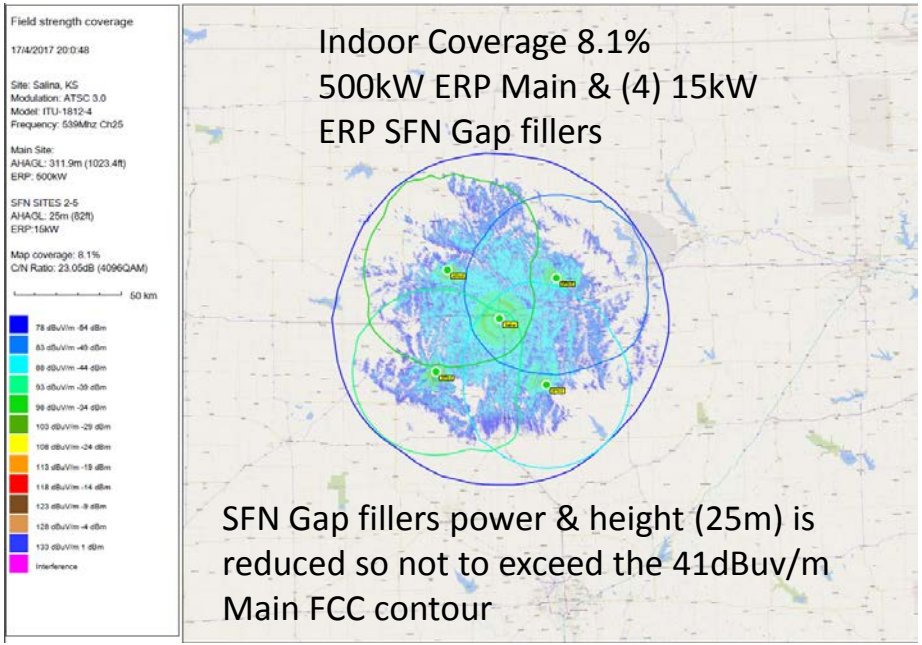
ATSC 3.0 MULTIPLE PHYSICAL LAYER PIPE LINES

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)





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?