FUTURE ANTENNA TECHNOLOGY FOR ATSC 3.0

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Dielectric®

More, More, More

ATSC 3.0

- More flexibility
- More services
- More robust delivery
- More platforms

4K
UHDTV

More signal strength

How much signal strength is required?

95 dBu

25 Mbit Deep indoor mobile to small handheld receiver

?

Outdoor reception of the Bootstrap signal

48 dBu

Boosting the signal strength

1. Increase transmitter power
2. Increase beam tilt
3. Increase null fill
4. Add a SFN
5. Provide diversity gain through MISO

Co-located MISO
Diversity gain throughout

Distributed MISO
Diversity gain in overlap area

Rx

Rx

Tx_1
Tx_2

Tx_1

Tx_2

Effect of heavy beam tilt

Effect of heavy null fill

Relative field strength(dbu)

130
120
110
100
90
80
70
60

1   10   100

Distance from antenna (miles)

Relative field strength(dbu)

130
120
110
100
90
80
70
60
50
40
30

1   10   100

Distance from antenna (miles)

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Provide even distribution of high signal strength

- Saturate in the vicinity of the main antenna by increasing the null fill
- Add SFN sited around coverage perimeter to boost the signal strength outside of the high null fill area

Adding null fill and future proofing the main stick

In anticipation of ATSC 3.0 services, future proofing should be considered if purchasing an antenna now.

"FutureFill"

Simply increase the null fill of your antenna later

Field convertible null fill antenna

- Simple
- Short conversion time
- VSWR performance is unaffected

Superimposing an out of phase excitation

$|I_{(z)}|$

Equal amplitude

180 deg

$-\dfrac{L}{2}$ $\dfrac{L}{2}$ z

$I_{(z)}$

$\dfrac{5}{8}L$ L

θ

$\pi \dfrac{L}{\lambda} sin\theta_0$

$-\dfrac{L}{2}$

$\dfrac{L}{2}$ z

$-\pi \dfrac{L}{\lambda} sin\theta_0$

$I_{(Z)}$

Linear phase

If phase disturbance is 180 degrees then the starting beam tilt is unaffected

Increase null fill

Lead to the development of custom illuminations with standard null fill that react positively to this theory

All high power UHF antennas will have the FutureFill feature

"FutureFill"

Boosting the signal strength

Field convertible high null fill antenna using a future proof illumination

- Simple
- Short conversion time
- VSWR performance is unaffected

Boosting the signal strength

First shipped antenna with FutureFill

KPPX – TFU-23 JTH/VP-R O4 channel 31 – Phoenix AZ.

Measured results

7 dB avg. increase in null fill

Chart legend (left): Proposed pattern; Measured pattern; Measured FutureFill pattern; Measured FutureFill pattern TPO +1.3dB

Chart legend (right): Final measured Z; Measured Z after FutureFill Change

Adding Null Fill and a SFN Planning the ATSC 3.0 Network

Example – WNUV, Baltimore

WNUV ATSC 3.0 Network Example

- CRC propagation model
    - Communication Research Center – Canada
    - More realistic than Longley Rice
    - Uses clutter data
- Services - RSS needed at 30' receive antenna height
    - Analysis to cover 48dBu < RSS < 95dBu
- Network areas limited within the FCC 41dBu contour or 103km from main antenna
    - 47 CFR 73.626 – DTV distributed transmission systems
- SFN Tower search
    - All towers in the search are available
    - Towers located >10 km inside 103km circle
    - Restricted to tower heights > 60 m
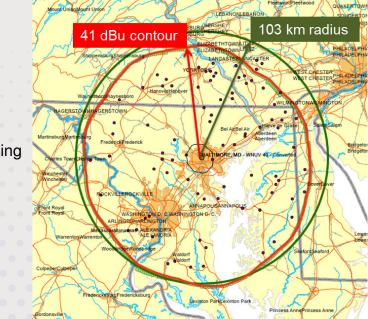- PROGIRA plan network planning tool
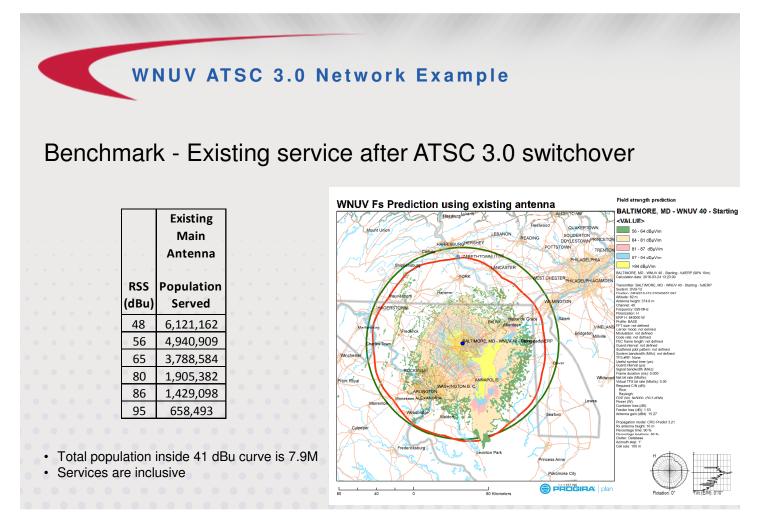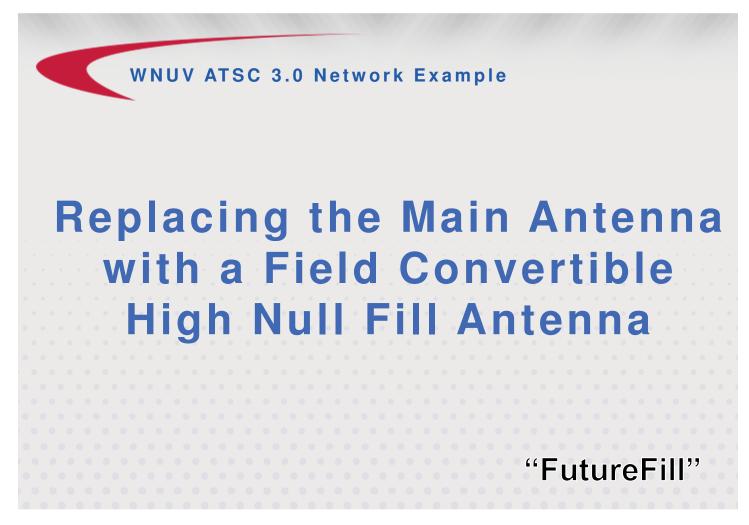
WNUV ATSC 3.0 Network Example

Goal

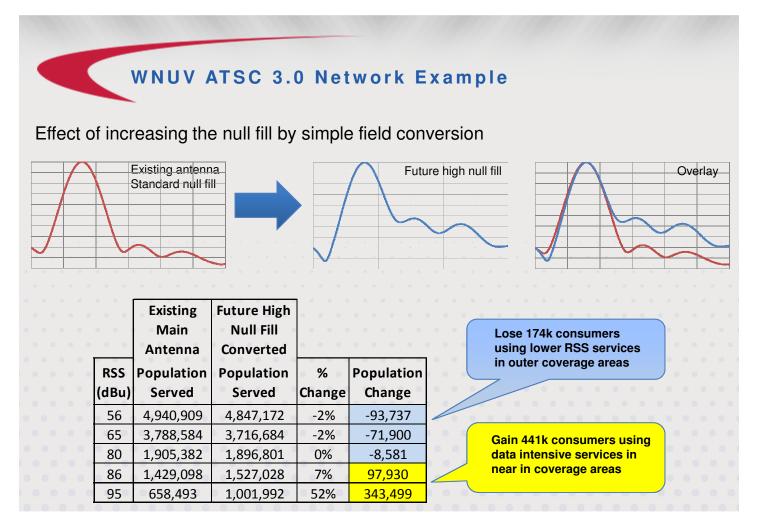- **Boost signal strength and provide more services to more people**
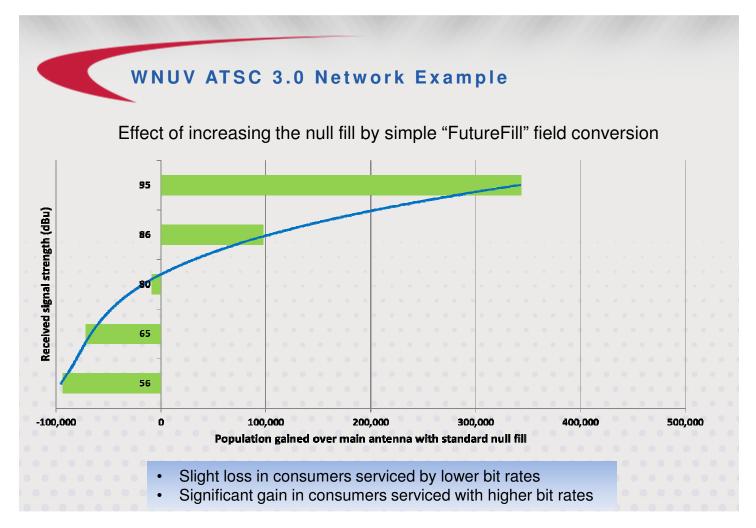
Assume

- Replace antenna with a high null fill field convertible antenna
- Main antenna retains full ERP - 845 kW
- Main antenna remains at full HAAT - 1200'
- Strategically add SFN to coverage area using existing towers.

41 dBu contour

103 km radius

Benchmark - Existing service after ATSC 3.0 switchover

RSS (dBu)	Existing Main Antenna Population Served
48	6,121,162
56	4,940,909
65	3,788,584
80	1,905,382
86	1,429,098
95	658,493

- Total population inside 41 dBu curve is 7.9M
- Services are inclusive

WNUV Fs Prediction using existing antenna

Field strength prediction

BALTIMORE, MD - WNUV 40 - Starting
<VALUE>

- 56 - 64 dBμV/m
- 64 - 81 dBμV/m
- 81 - 87 dBμV/m
- 07 - 94 dBμV/m
- >94 dBμV/m

BALTIMORE, MD - WNUV 40 - Starting - fullERP (90% 10m)
Calculation date: 2016-03-24 13:23:00
Transmitter: BALTIMORE, MD - WNUV 40 - Starting - fullERP
System: DVB-T2
Position: 39N2610.412 070W0057.097
Altitude: 82 m
Antenna height: 374.8 m
Channel: 40
Frequency: 629 MHz
Polarization: H
ERP H: 845000 W
Profile: BASE
FFT size: not defined
Carrier mode: not defined
Modulation: not defined
Code rate: not defined
FEC frame length: not defined
Guard interval: not defined
Scattered pilot pattern: not defined
System bandwidth (MHz): not defined
TFS #RF: None
Useful symbol time (μs):
Guard interval (μs):
Signal bandwidth (MHz):
Frame duration (ms): 0.000
Net bit rate (Mbit/s):
Virtual TFS bit rate (Mbit/s): 0.00
Required C/N (dB):
  Rice:
  Rayleigh:
ERP (W): 845000 (59.3 dRW)
Power (W):
Combiner loss (dB):
Feeder loss (dB): 1.53
Antenna gain (dBd): 15.27

Propagation model: CRC-Predict 3.21
Rx antenna height: 10 m
Percentage time: 90 %
Percentage locations: 60 %
Clutter: Database
Azimuth step: 1°
Cell size: 100 m

Rotation: 0°   Tilt (E/M): 0°/0°

80   40   0   80 Kilometers

PROGIRA | plan

WNUV ATSC 3.0 Network Example

Replacing the Main Antenna with a Field Convertible High Null Fill Antenna

"FutureFill"

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WNUV ATSC 3.0 Network Example

Effect of increasing the null fill by simple field conversion

Existing antenna
Standard null fill

Future high null fill

Overlay

RSS (dBu)	Existing Main Antenna Population Served	Future High Null Fill Converted Population Served	% Change	Population Change
56	4,940,909	4,847,172	-2%	-93,737
65	3,788,584	3,716,684	-2%	-71,900
80	1,905,382	1,896,801	0%	-8,581
86	1,429,098	1,527,028	7%	97,930
95	658,493	1,001,992	52%	343,499

Lose 174k consumers using lower RSS services in outer coverage areas

Gain 441k consumers using data intensive services in near in coverage areas

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WNUV ATSC 3.0 Network Example

Effect of increasing the null fill by simple "FutureFill" field conversion

- Slight loss in consumers serviced by lower bit rates
- Significant gain in consumers serviced with higher bit rates

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WNUV ATSC 3.0 Network Example

Adding SFN Sites to the Existing Main Antenna

WNUV ATSC 3.0 Network Example

Adding 50 kW ERP SFN sites with theoretical antenna patterns

Site 1
75m Tower
50 kW ERP

Site 2
75m Tower
50 kW ERP

Site 3
75m Tower
50 kW ERP

Site 4
100m Tower
50 kW ERP

Each site begins omni directional then applies power reductions to meet FCC 41 limits

WNUV ATSC 3.0 Network Example

Effect of adding theoretical SFN sites to the main antenna with standard null fill elevation pattern

RSS (dBu)	Existing Main Antenna Population Served	Standard Elevation Pattern + SFN Population Served	% Change	Population Change
56	4,940,909	5,405,598	9%	464,689
65	3,788,584	4,189,184	11%	400,600
80	1,905,382	2,157,756	13%	252,374
86	1,429,098	1,702,093	19%	272,995
95	658,493	734,238	12%	75,745

Gain 1.46M consumers throughout service offerings

WNUV ATSC 3.0 Network Example

Effect of adding theoretical SFN sites to the main antenna with standard elevation pattern

- Significant gain in consumers serviced by lower bit rates
- Slight gain in consumers serviced with higher bit rates

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Converting to High Null Fill and Adding SFN Sites

WNUV ATSC 3.0 Network Example

Effect of adding SFN sites and increasing the null fill of the main antenna

RSS (dBu)	Existing Main Antenna Population Served	Future High Null Fill Converted + SFN Population Served	% Change	Population Change
56	4,940,909	5,283,509	7%	342,600
65	3,788,584	4,099,525	8%	310,941
80	1,905,382	2,142,988	12%	237,606
86	1,429,098	1,760,761	23%	331,663
95	658,493	1,077,222	64%	418,729

Gain 1.64M consumers throughout service offerings

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WNUV ATSC 3.0 Network Example

Effect of adding SFN sites and increasing the null fill of the main antenna

- Significant gain in consumers serviced by both lower and high bit rates

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Conclusion

- ATSC 3.0 services will require a new definition of received signal strengths

- Through the use of high null fill plus the addition of SFN sites, these required signal strengths can be achieved