FUTURE ANTENNA TECHNOLOGY FOR ATSC 3.0

John L. Schadler

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Trusted for Decades. Ready for Tomorrow.

More, More, More

Fundamentally changing the way U.S. Broadcast TV is delivered.

Merging internet with broadcast with
- More flexibility
- More services
- More robust delivery
- More platforms

More bits to more places

More signal strength

Signal strength approximation

Purpose is not to establish next generation planning factors

FCC ATSC A/53 minimum field strength	**41 dBu**
Reduce antenna height 30ft. to 6ft. (Suburban) [1]	14 dB
Building wall attenuation (5-28 dB) [2]	8 dB
Smaller inefficient receive antenna gain (-3 dBd)	9 dB
Multipath (AWGN to Ricean / Rayleigh) (1-3 dB) [3]	3 dB
Location correction F(95%,fade margin) [4]	9 dB
Estimated minimum required field strength for an indoor NG broadcast service to support a data rate based on 15 dB C/N	**84 dBu**

Based on
- Outdoor
- Fixed antenna at 30’
- 6dB gain (10dB-4dB down lead)
- C/N 15 dB

[1] ITU-R BT.2137 Coverage prediction methods and planning software for digital terrestrial television broadcasting networks
[2] TV Technology: “DTV in the House, Part1”, Doug Lung, Sept 5, 2007
[3] ITU-R BT.2033-1, “Planning criteria, including protection ratios, for second generation of digital terrestrial television broadcasting systems in the VHF/UHF bands”; “Effect of AWGN & Fading (Rayleigh & Rician) channels on BER performance of a WiMAX communication System, IJCSIS, Awon, Islam, Rahman and Islam
[4] ITU-R P.1546-5 Method for point to area predictions for terrestrial services in the frequency range 30MHz to 3000 MHz.

Signal strength requirements for types of service

Designing for coverage – old school thinking

Designing for service

Focus on consumers served

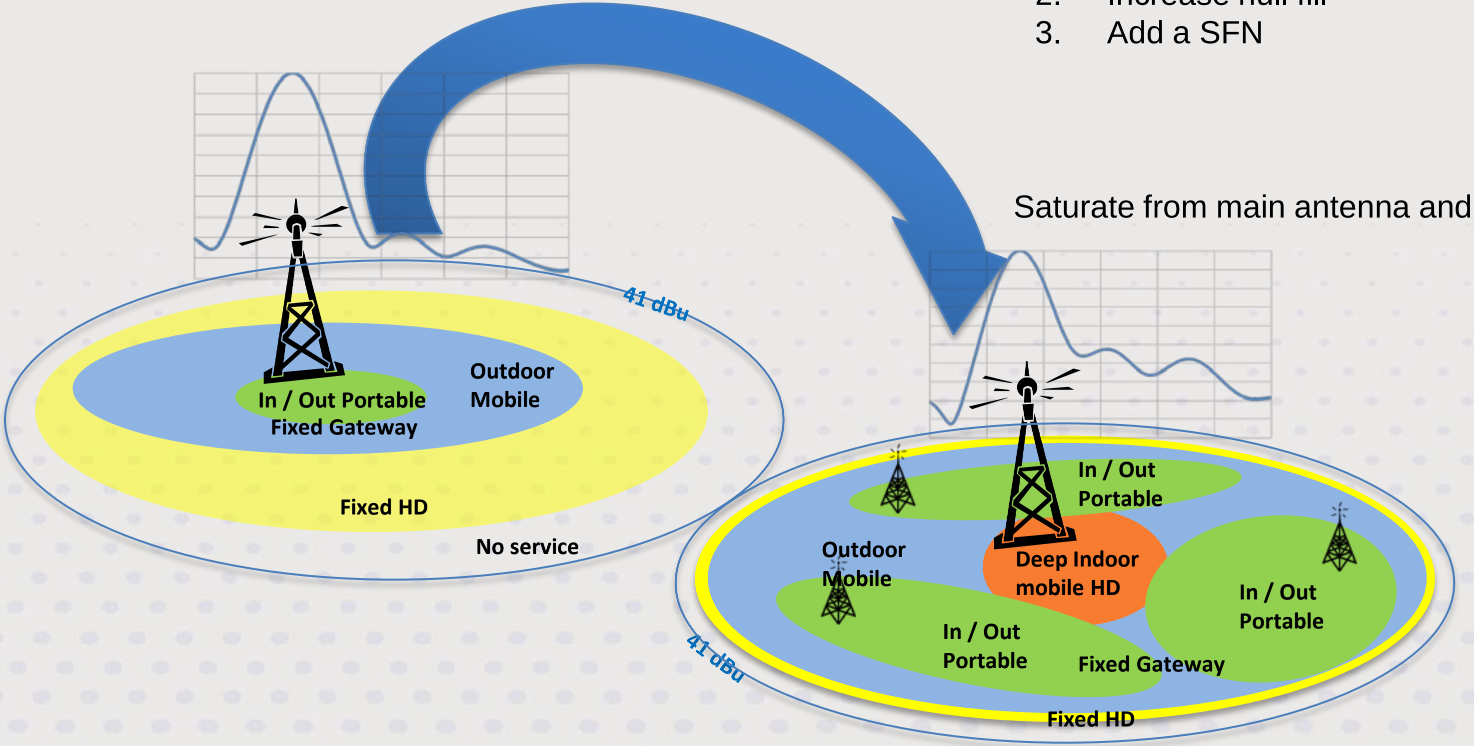
Type of Service

	Inputs	Deep indoor mobile HD 25 Mbps	Fixed indoor Gateway HD 25 Mbps	Indoor Nomadic - Portable 10 Mbps	Outdoor mobile 5 Mbps	Outdoor fixed HD 25 Mbps	Rural Auto Bootstrp
FCC ATSC A/53 minimum field strength (dBu)	41	41	41	41	41	41	41
Reduce antenna height factor 30 to "X" ft. (dB)	14 Suburban X=6'	19 Urban X=6'	17 Urban X=8'	17 Suburban X=4.5'	14 Suburban X=6'	3 Rural X=18'	10 Rural X=5'
Building wall attenuation (dB)	8	15	5	15	N/A	N/A	N/A
Smaller inefficient receive antenna gain factor (dB)	9	9	6	6	9	3	6
Dynamic multipath - AWGN to Ricean/Rayleigh (dB)	3	3	3	3	3	1	3
Location correction F(95% or 99%,fade margin)	9	9	9	9	9	9	13
Required C/N (dB)	15	14	14	10	4	14	-10
C/N Correction (dB)	-15	-15	-15	-15	-15	-15	-15
Total - Required signal strength at 30' (dBu)	**84**	**95**	**80**	**86**	**65**	**56**	**48**

Boosting the signal strength

1. ~~Increase beam tilt and add lots of power~~
2. Increase null fill
3. Add a SFN

Saturate from main antenna and add SFN sites



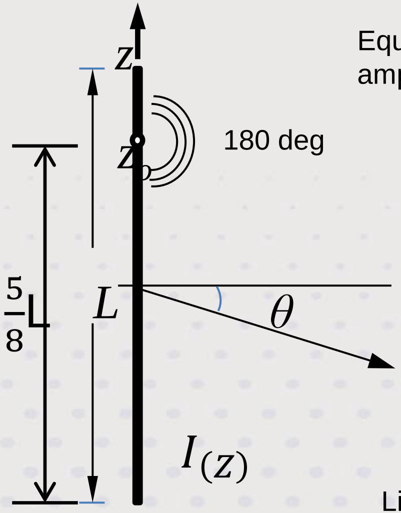
Adding null fill and future proofing the main stick

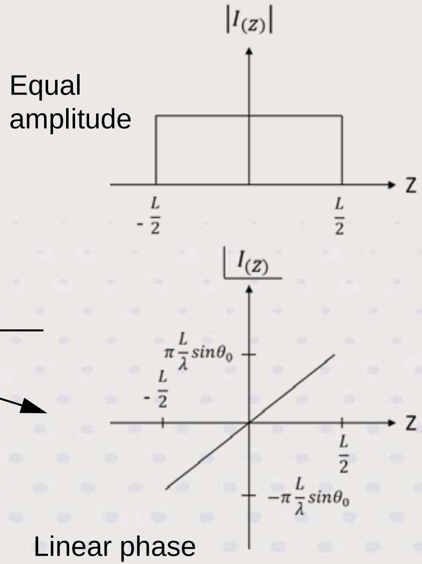
In anticipation of ATSC 3.0 services, future proofing should be considered if purchasing an antenna now.

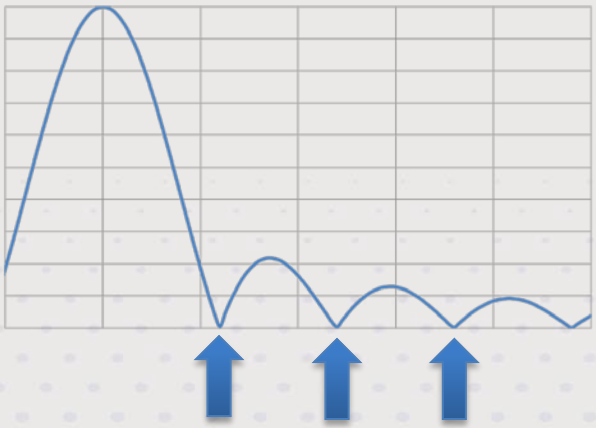
Field convertible null fill antenna "FutureFill"

Simply increase the null fill of your antenna later

Superimposing an out of phase excitation





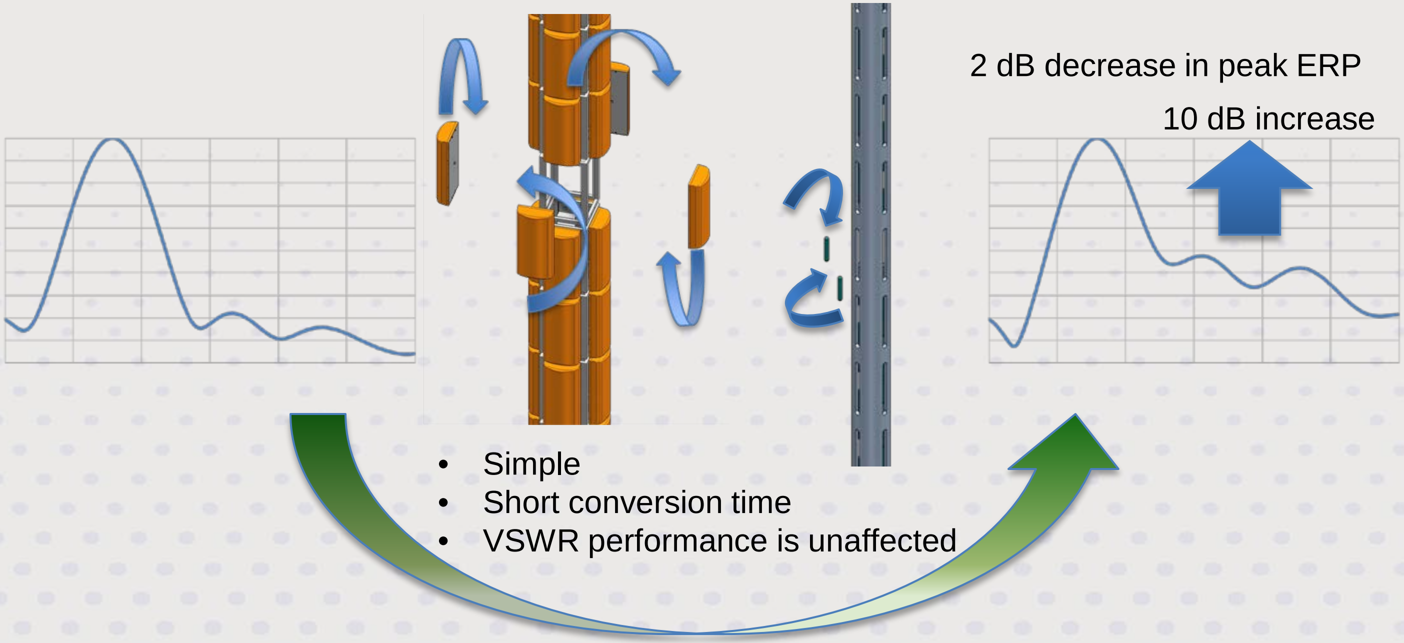


Lead to the development of custom illuminations with standard null fill that react positively to this theory

"FutureFill"

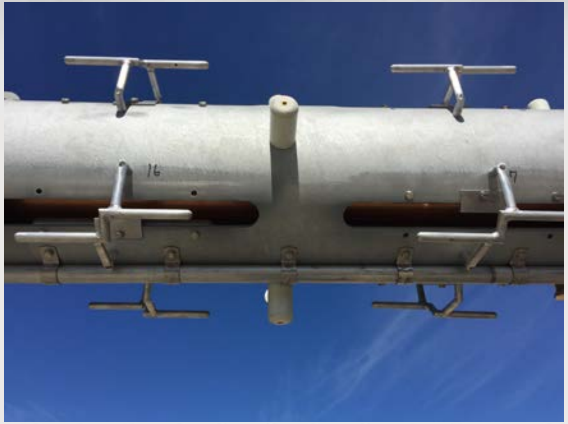
Boosting the signal strength

Field convertible high null fill antenna using a future proof illumination



- Simple
- Short conversion time
- VSWR performance is unaffected

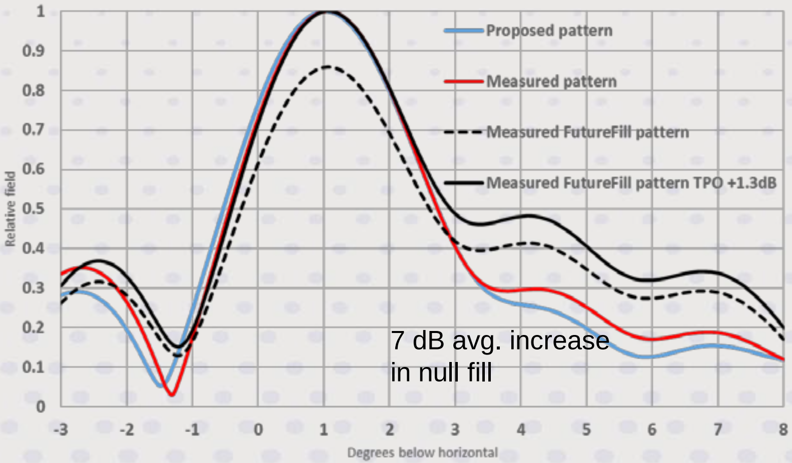
Boosting the signal strength



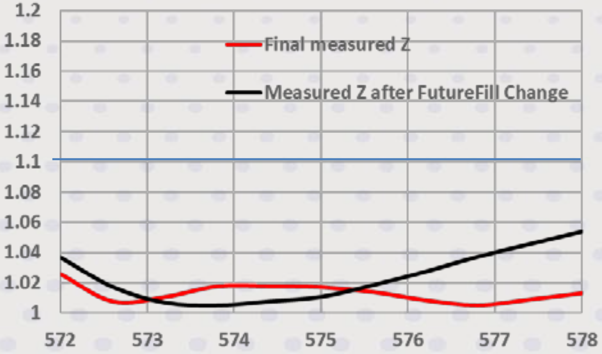
First shipped antenna with FutureFill

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

Measured results



7 dB avg. increase
in null fill



Adding Null Fill and a SFN Planning the ATSC 3.0 Network

Network planning assumptions / settings

- CRC propagation model
  - Communication Research Center – Canada
  - More realistic than Longley Rice
  - Uses clutter data
- Services / Bitrate / RSS needed at 30’ receive antenna height
    - Outdoor fixed HD / 25 Mbs / 56 dBu
    - Outdoor mobile / 5 Mbs / 65 dBu
    - Fixed indoor gateway HD / 25 Mbs / 80 dBu
    - Indoor nomadic-portable / 10 Mbs / 86 dBu
    - Deep indoor mobile HD / 25 Mbs / 95 dBu
- Network areas limited within the FCC 41 dBu contour or 103km from main antenna
  - 47 CFR 73.626 – DTS 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

Boosting the signal strength

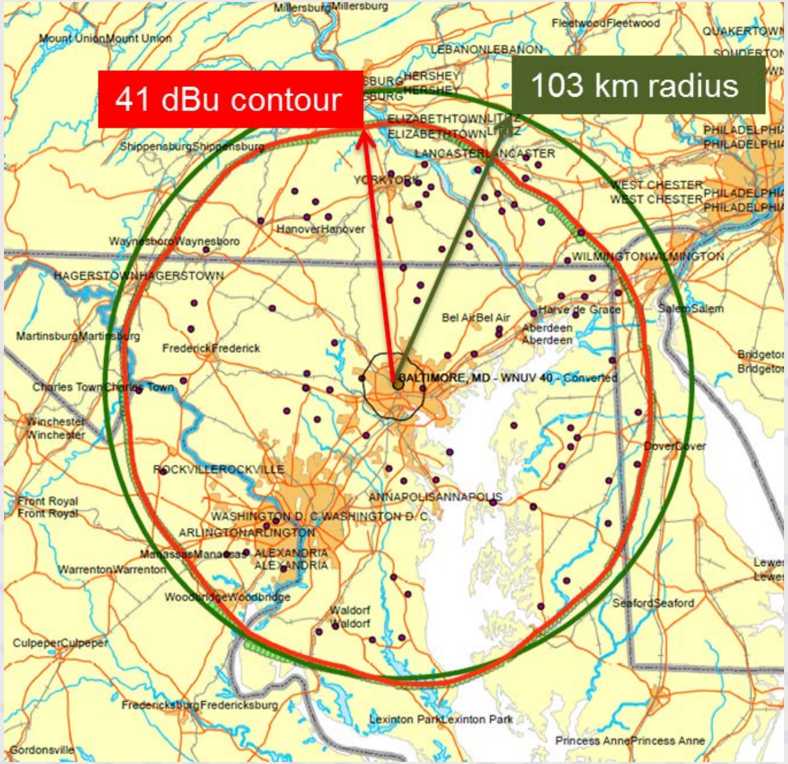
WNUV – Baltimore Example

Goal

- **Boost signal strength and provide more services to more people**
- Provide deep indoor mobile HD in close to highly populated areas
- Provide indoor portable service in targeted areas
- Expand outdoor mobile services

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.

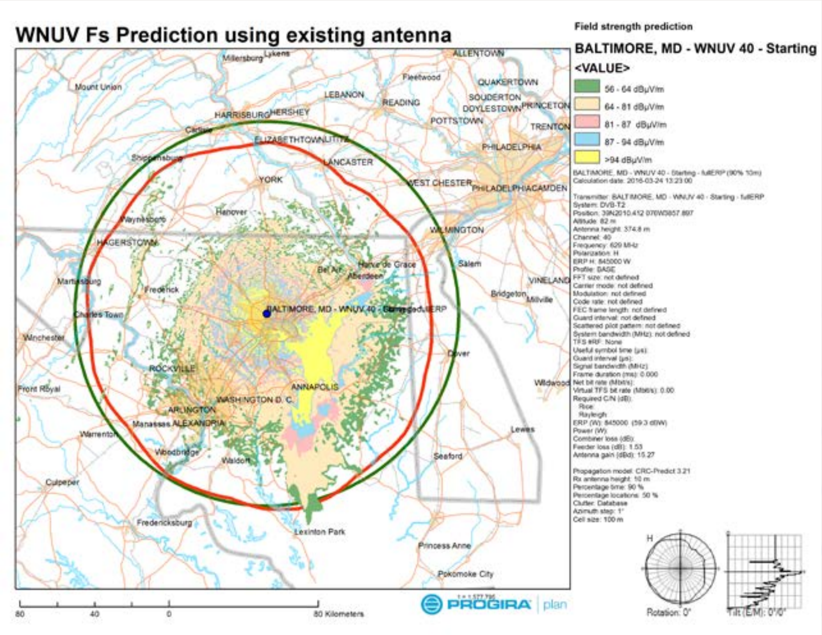


WNUV – Baltimore Example

Existing service after ATSC 3.0 switchover

Service	RSS (dBu)	Existing Main Antenna Population Served
Bootstrap	48	6,121,162
Outdoor fixed HD	56	4,940,909
Outdoor mobile	65	3,788,584
Fixed indoor gateway HD	80	1,905,382
Indoor nomadic-portable	86	1,429,098
Deep indoor mobile HD	95	658,493

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

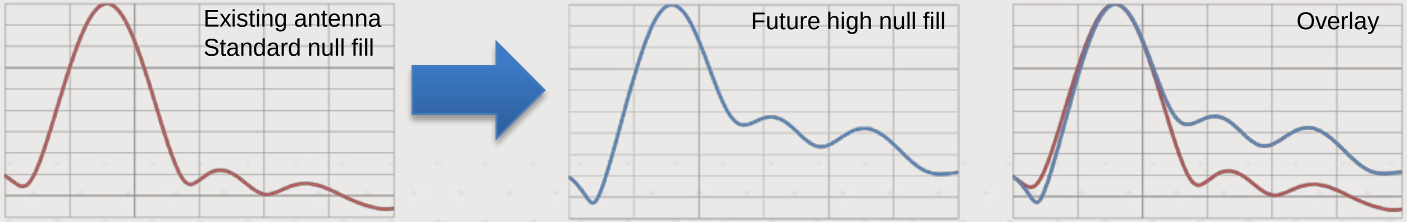


Replacing the Main Antenna with a Field Convertible High Null Fill Antenna

"FutureFill"

WNUV – Baltimore Example

Effect of increasing the null fill by simple field conversion



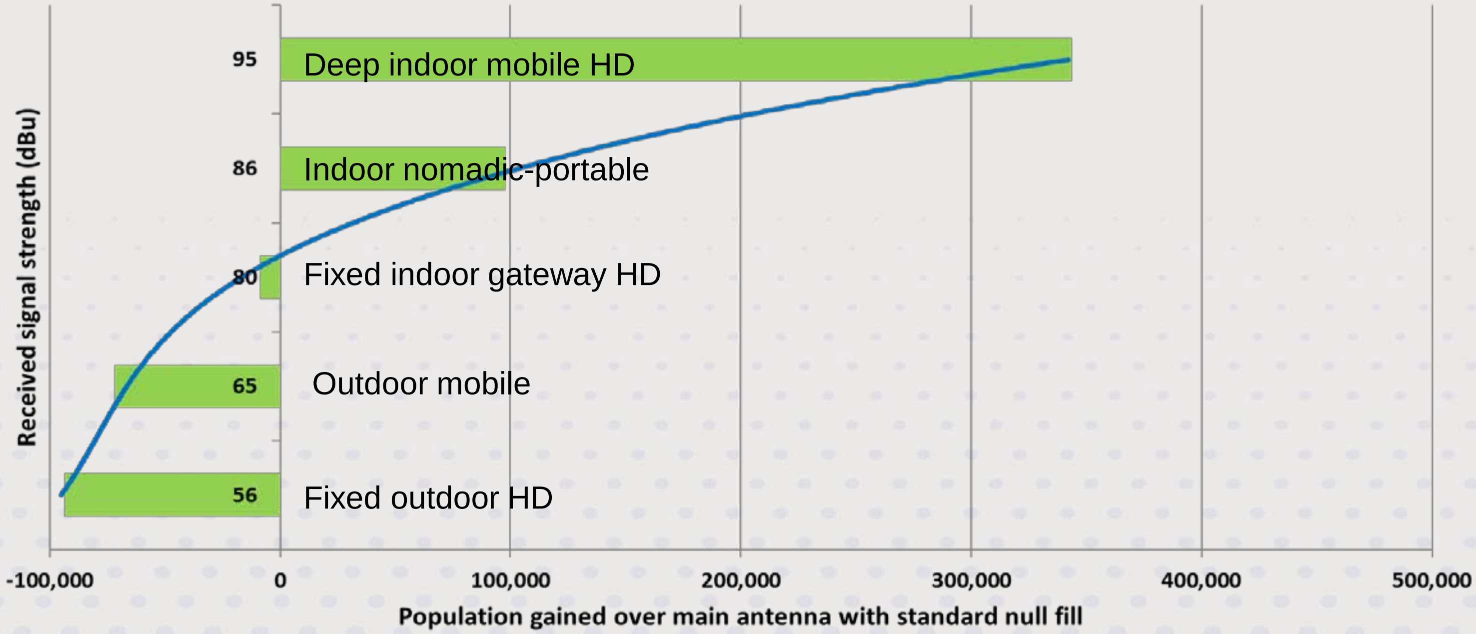
Service	RSS (dBu)	Existing Main Antenna Population Served	Future High Null Fill Converted Population Served	% Change	Population Change
Outdoor fixed HD	56	4,940,909	4,847,172	-2%	-93,737
Outdoor mobile	65	3,788,584	3,716,684	-2%	-71,900
Fixed indoor gateway HD	80	1,905,382	1,896,801	0%	-8,581
Indoor nomadic-portable	86	1,429,098	1,527,028	7%	97,930
Deep indoor mobile HD	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

WNUV – Baltimore Example

Effect of increasing the null fill by simple field conversion



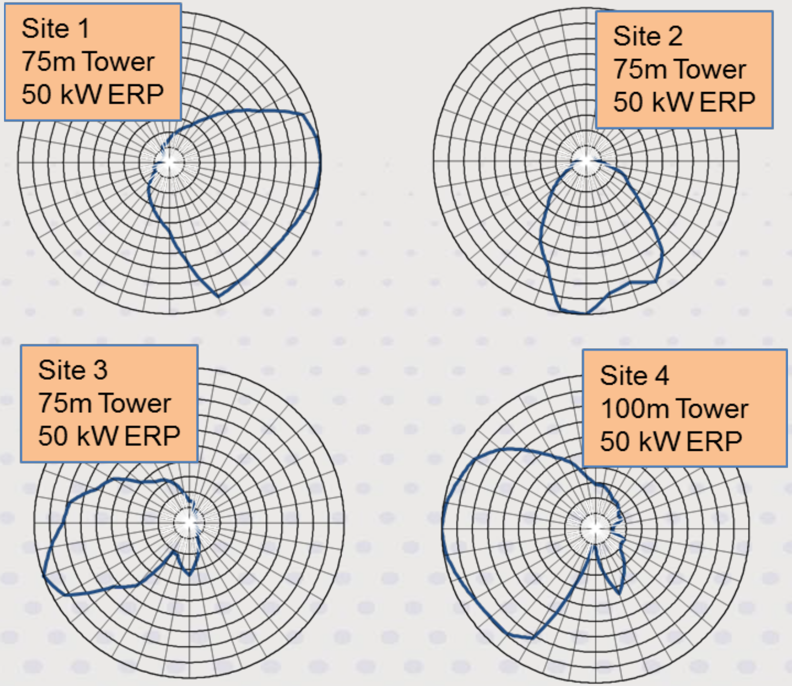
- Slight loss in consumers serviced by lower bit rates
- Significant gain in consumers serviced with higher bit rates

Adding SFN Sites to the Existing Main Antenna

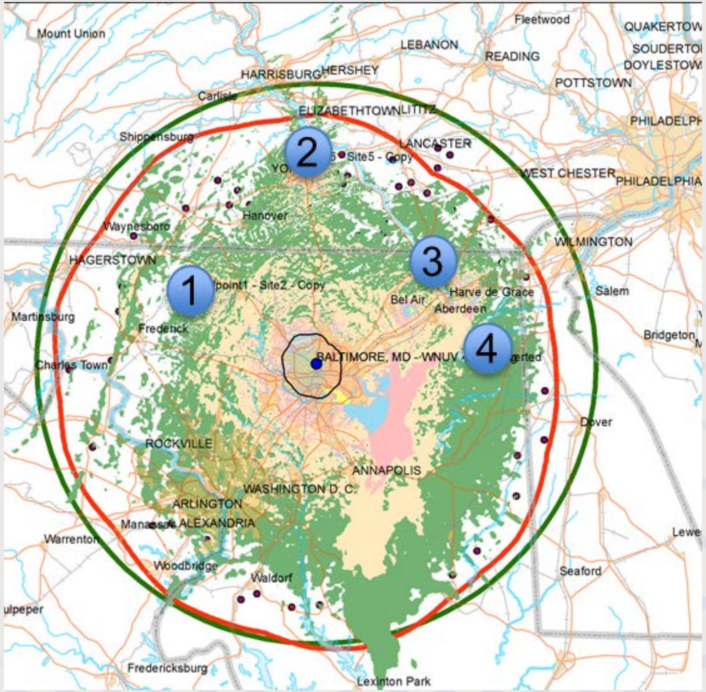
Boosting the signal strength

WNUV – Baltimore Example

Adding 50 kW ERP SFN sites with theoretical antenna patterns



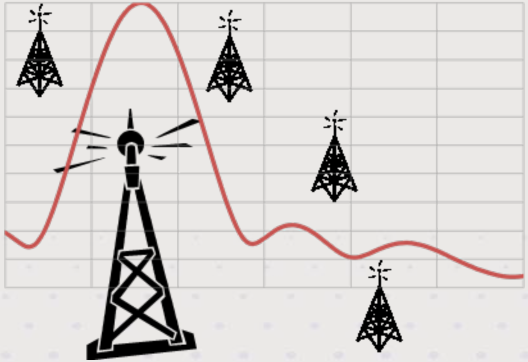
Each site begins omni directional then applies power reductions to meet FCC 41 limits



Boosting the signal strength

WNUV – Baltimore Example

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



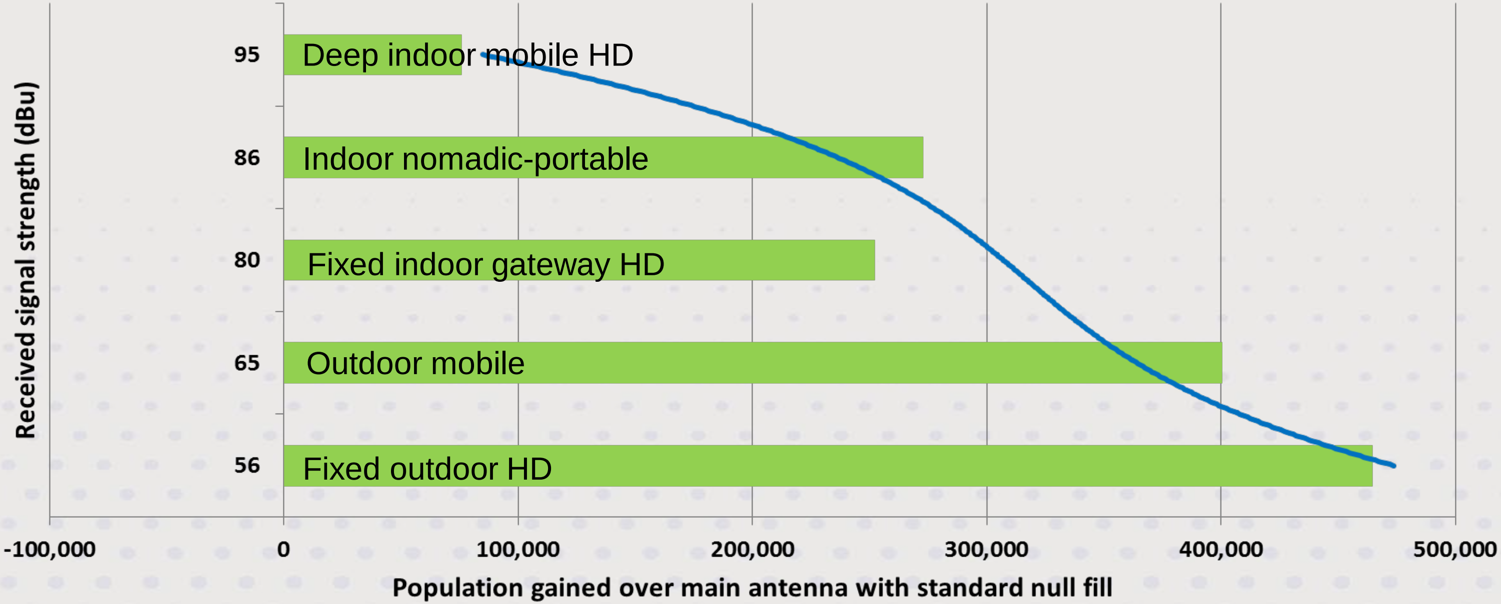
Service	RSS (dBu)	Existing Main Antenna Population Served	Standard Elevation Pattern + SFN Population Served	% Change	Population Change
Outdoor fixed HD	56	4,940,909	5,405,598	9%	464,689
Outdoor mobile	65	3,788,584	4,189,184	11%	400,600
Fixed indoor gateway HD	80	1,905,382	2,157,756	13%	252,374
Indoor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

Gain 1.46M consumers throughout service offerings

Boosting the signal strength

WNUV – Baltimore Example

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



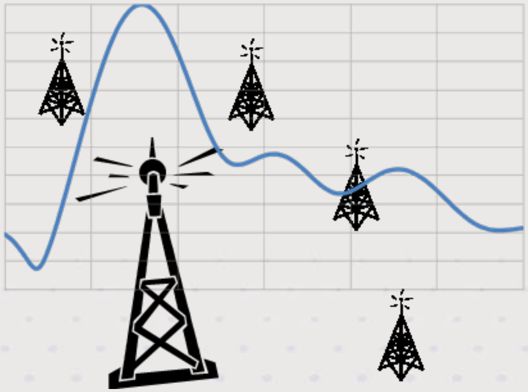
- Significant gain in consumers serviced by lower bit rates
- Slight gain in consumers serviced with higher bit rates

Converting to High Null Fill and Adding SFN Sites

Boosting the signal strength

WNUV – Baltimore Example

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



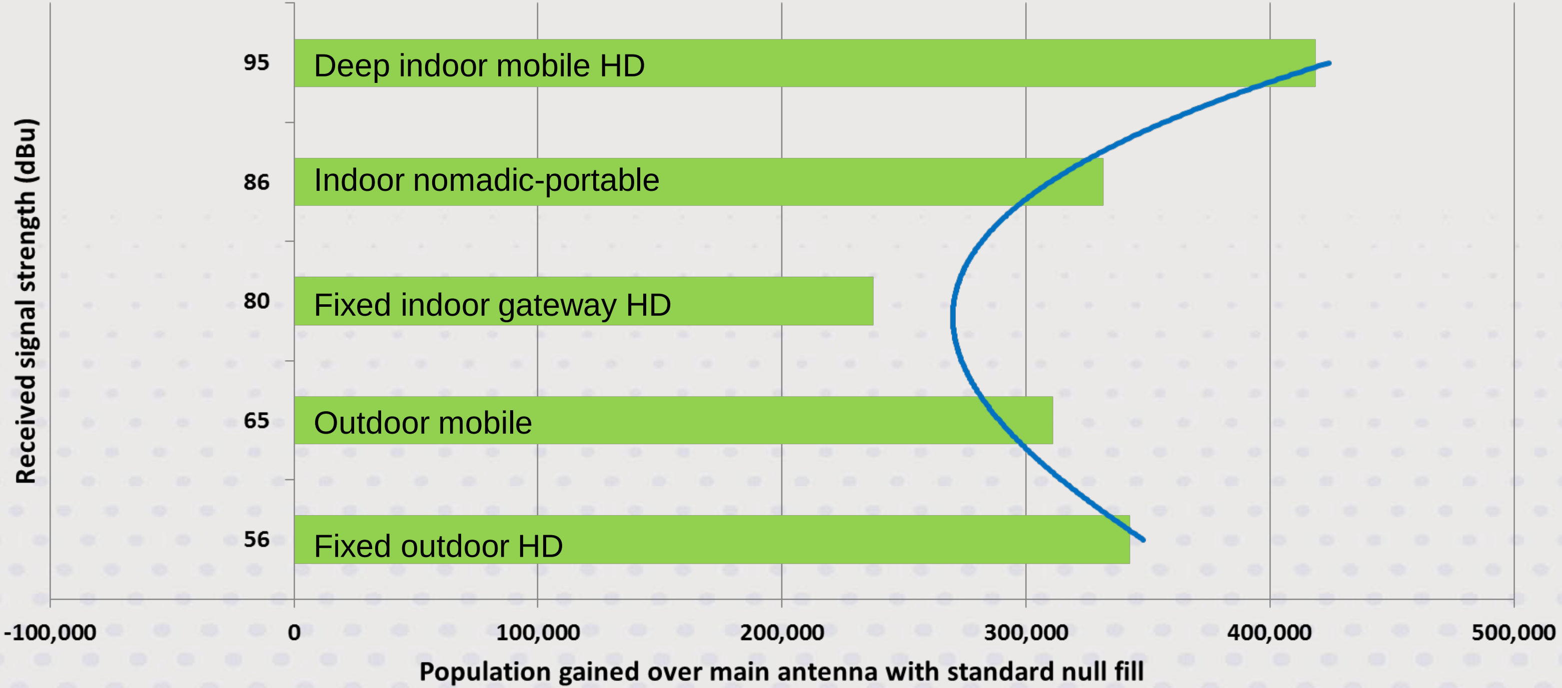
Service	RSS (dBu)	Existing Main Antenna Population Served	Future High Null Fill Converted + SFN Population Served	% Change	Population Change
Outdoor fixed HD	56	4,940,909	5,283,509	7%	342,600
Outdoor mobile	65	3,788,584	4,099,525	8%	310,941
Fixed indoor gateway HD	80	1,905,382	2,142,988	12%	237,606
Indoor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

Gain 1.64M consumers throughout service offerings

Boosting the signal strength

WNUV – Baltimore Example

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



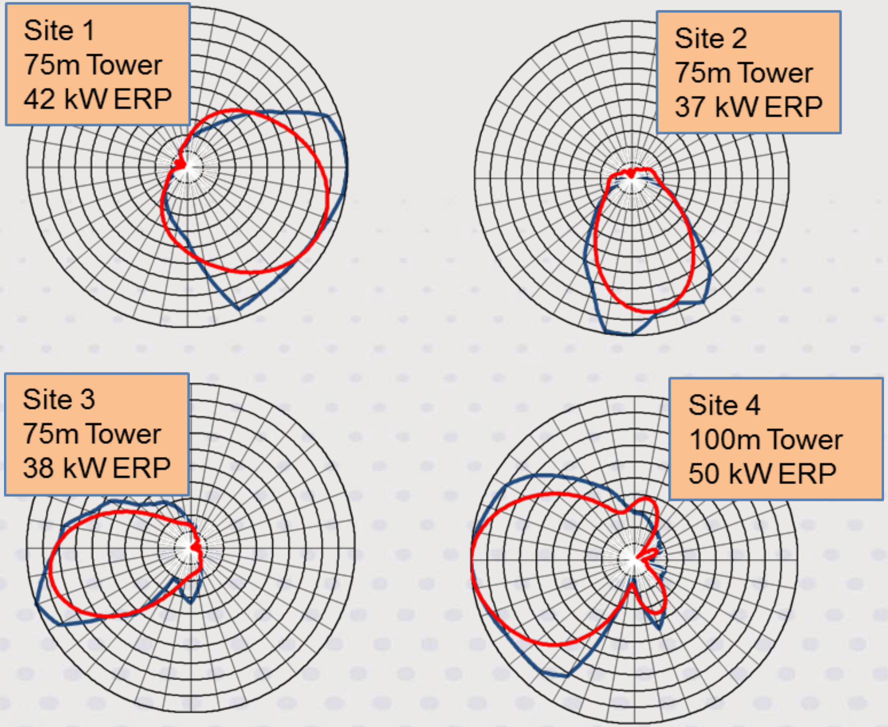
- Significant gain in consumers serviced by both lower and high bit rates

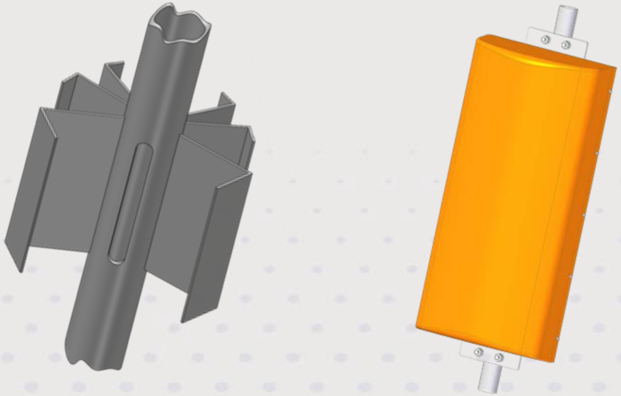
Replacing Theoretical Antenna Patterns with Real Designs

Boosting the signal strength

WNUV – Baltimore Example

Replacing SFN sites with antenna designs that closely replicate the theoretical patterns





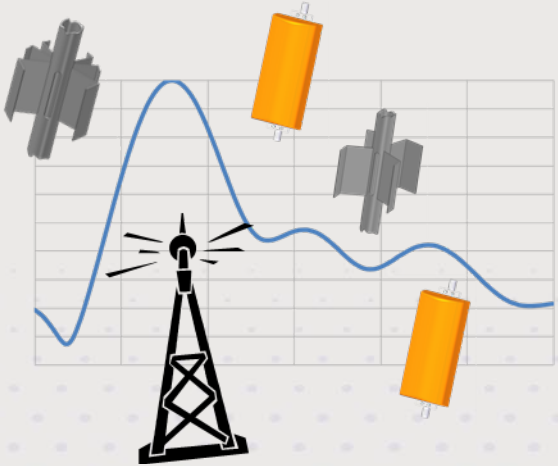
Combination of panel and slot antenna designs

Boosting the signal strength

WNUV – Baltimore Example

Effect of changing SFN sites to real antenna designs and increasing the null fill of the main antenna

Service	RSS (dBu)	Existing Main Antenna Population Served	Future High Null Fill Converted + Real Ant. SFN Population Served	% Change	Population Change
Outdoor fixed HD	56	4,940,909	5,276,767	7%	335,858
Outdoor mobile	65	3,788,584	4,095,082	8%	306,498
Fixed indoor gateway HD	80	1,905,382	2,123,632	11%	218,250
Indoor nomadic-portable	86	1,429,098	1,742,929	22%	313,831
Deep indoor mobile HD	95	658,493	1,065,715	62%	407,222



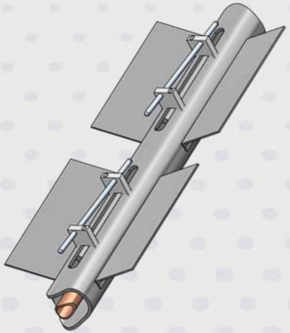
Gain 1.58M consumers throughout service offerings
Note :
Theoretical antennas gain = 1.64M

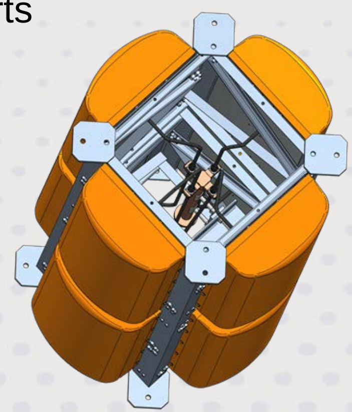
What type of antenna to use in the SFN network?

What type of antenna to use at the SFN sites?

Slotted coaxial vs. broadband panel antennas

- Slot Antennas:
  - Much smaller size
  - Less windload
  - Higher reliability
    - Less connections
    - Less parts



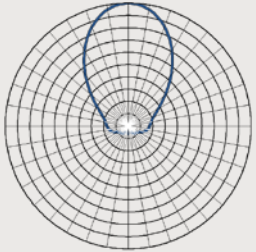


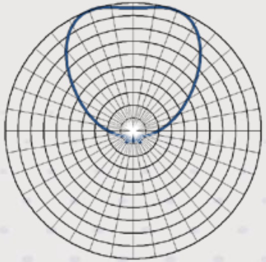
1966 RCA ad

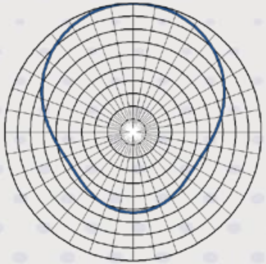
Disadvantage – Slotted coaxial antennas have a limited channel range

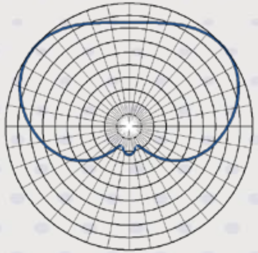
Slotted coaxial antennas

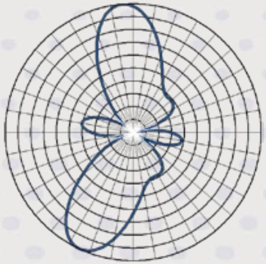
- Slotted coaxial antennas
  - Versatility - Azimuth patterns can be tailored to meet any coverage requirement
    - Pipe size
    - # of slots around
    - Orientation of slots
    - Power division between slots
    - Addition of fins and directors

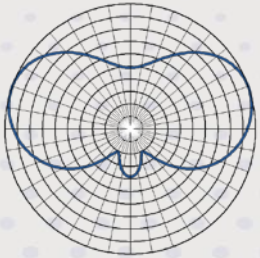


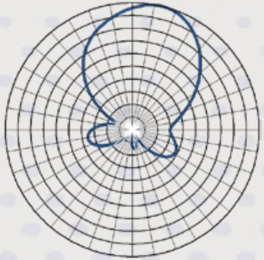


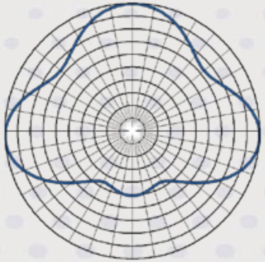






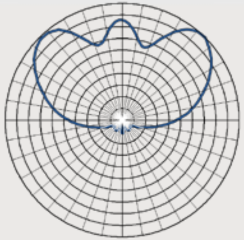
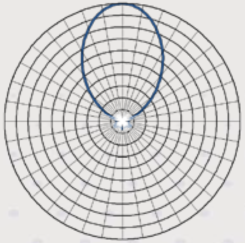
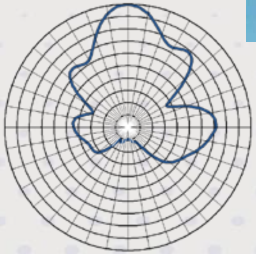
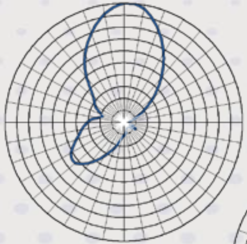
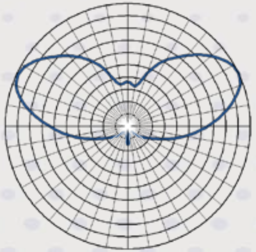
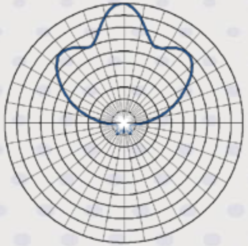
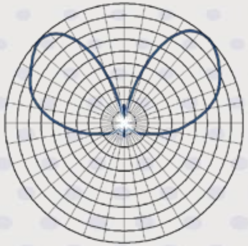
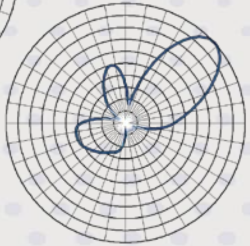
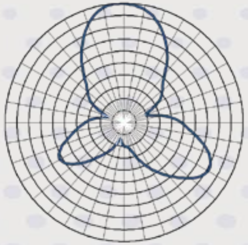






Broadband panel antennas

- Full UHF band operation
- Excellent choice for co-located shared SFN sites
- Very good pattern flexibility
  - Number of panels around
  - Location
  - Orientation
  - Amplitude and phase division
  - Element beam width

Broadband slot cavity antennas

Panel Bandwidth Performance in a Pylon Package

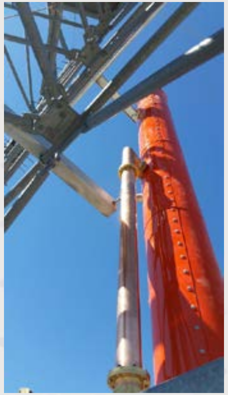
Pylon Antenna

+

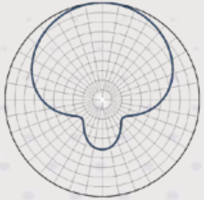
Panel Antenna

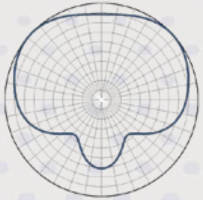
=

TFU-WB



- Broadband – Channels 14-51
- Low windload
- New w/g slot cavity technology
- Economical alternative to panels





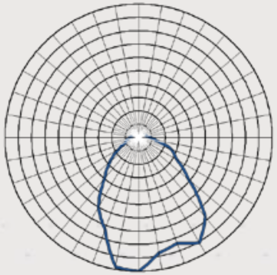
Broadcasted ATSC 3.0 from Black Mountain

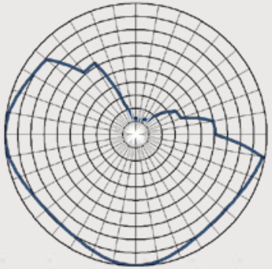
Disadvantage

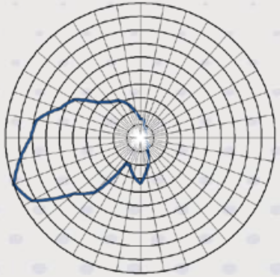
- Some loss in pattern flexibility
    - Single cavity limited to directional and cardioid variations

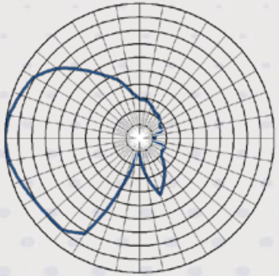
What type of antenna to use at the SFN sites?

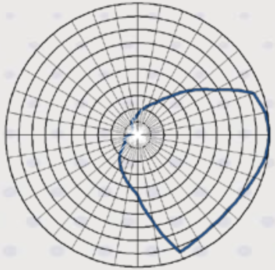
- Considerations
  - Azimuth pattern
  - Site sharing
  - Windload constraints









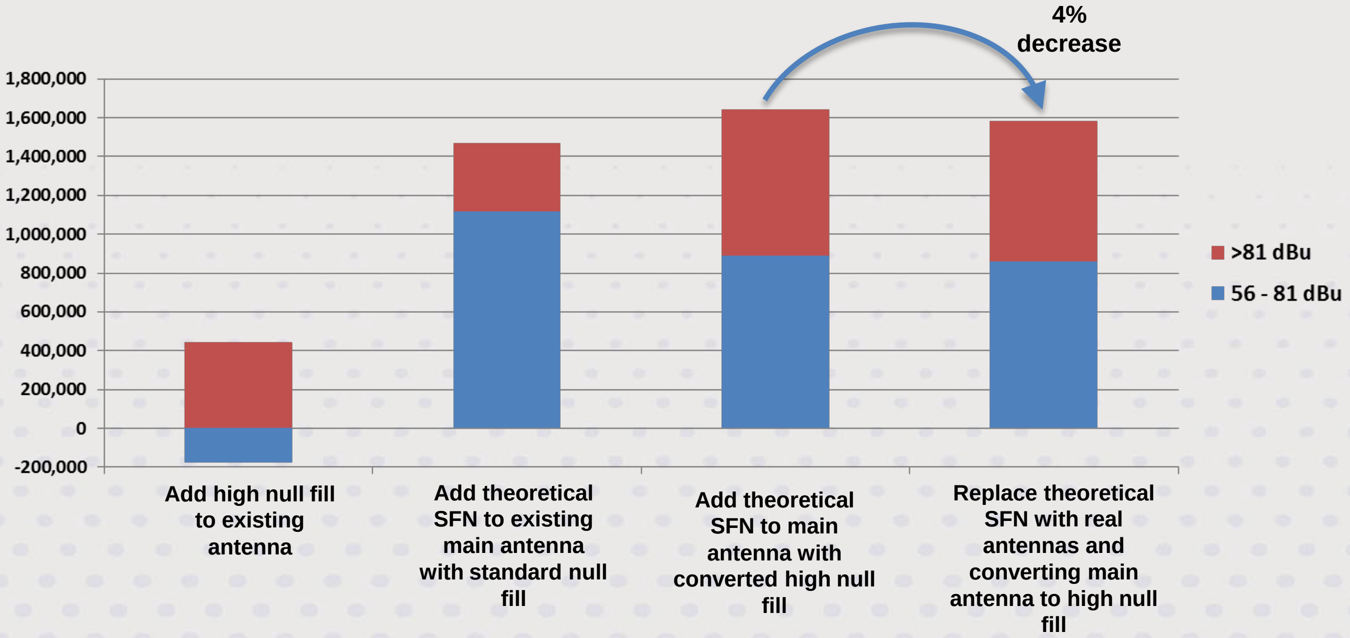


There is no “One Size Fits All” antenna solution for ATSC 3.0 SFN’s. A combination of panel, slot and broadband slot cavity antennas will be required

Summary

WNUV – Baltimore Example Summary

Population gained over using “as is” existing main antenna for ATSC 3.0 services



Conclusions

- ATSC 3.0 services will require a new definition of received signal strengths
- Through the use of advanced SFN planning tools and innovative antenna design, these required signal strengths can be achieved
- There is no “One Size Fits All” antenna solution for ATSC 3.0 SFN’s. A combination of panel, slot and broadband slot cavity antennas will be required

THANKS FOR YOUR TIME!

ANY QUESTIONS?

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