The Promise of the Next Generation Broadcast Standard, And More!

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Sinclair Broadcast Group

SBG

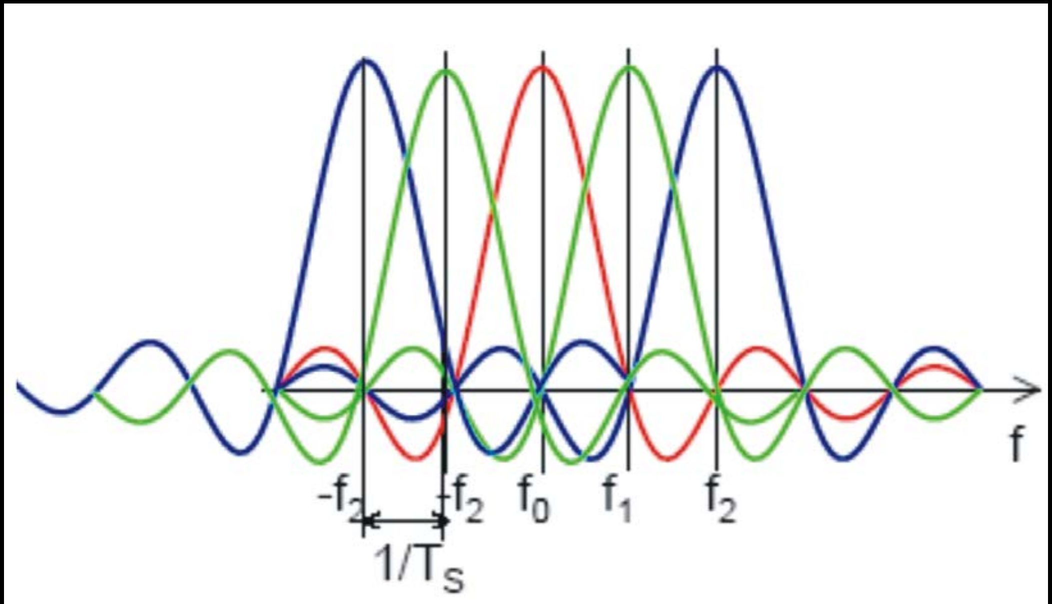
TYPICAL FAMILY SITTING DOWN TO AN EVENING OF TELEVISION...

COFDM

- Developed by the digital video broadcasting project group – DVB
- Uses multiple carriers
- Variable carrier modulation types are defined allowing high Payload data rates in 6 MHz
- Developed for 8 MHz channels
  - A 6 MHz variant has been produced and tested
- Can use single frequency networks - SFNs
- New technology with scope for continued improvement & development

What Is It?

- OFDM = Orthogonal FDM
- Carrier centers are put on orthogonal frequencies
- ORTHOGONALITY - The peak of each signal coincides with trough of other signals
- Subcarriers are spaced by 1/Ts



OFDM ADVANTAGES

- OFDM has an inherent robustness against narrowband interference.
  - Narrowband interference will affect at most a couple of subchannels.
  - Information from the affected subchannels can be erased and recovered via the forward error correction (FEC) codes.

- Equalization is very simple compared to Single-Carrier systems

OFDM ADVANTAGES

- Ability to comply with world-wide regulations:
  - Bands and tones can be dynamically turned on/off to comply with changing regulations.
- Coexistence with current and future systems:
  - Bands and tones can be dynamically turned on/off for enhanced coexistence with the other devices.

OFDM HAD MINUSES

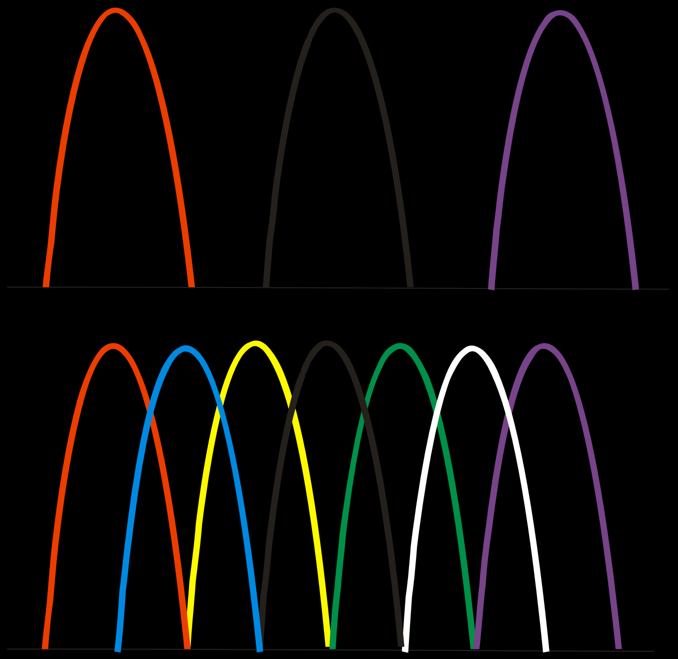
- High sensitivity inter-channel interference, ICI
- OFDM is sensitive to frequency, clock and phase offset
- The OFDM time-domain signal has a relatively large peak-to-average ratio
  - tends to reduce the power efficiency of the RF amplifier
  - non-linear amplification destroys the orthogonality of the OFDM signal and introduced out-of-band radiation

PRINCIPLES

- BASIC IDEA : Channel bandwidth is divided into multiple subchannels to reduce ISI and frequency-selective fading.
- Time-domain spreading:
  - Spreading is achieved in the time-domain by repeating the same information in an OFDM symbol on two different sub-bands => Frequency Diversity.
- Frequency-domain spreading:
  - Spreading is achieved by choosing conjugate symmetric inputs for the input to the IFFT (real output)

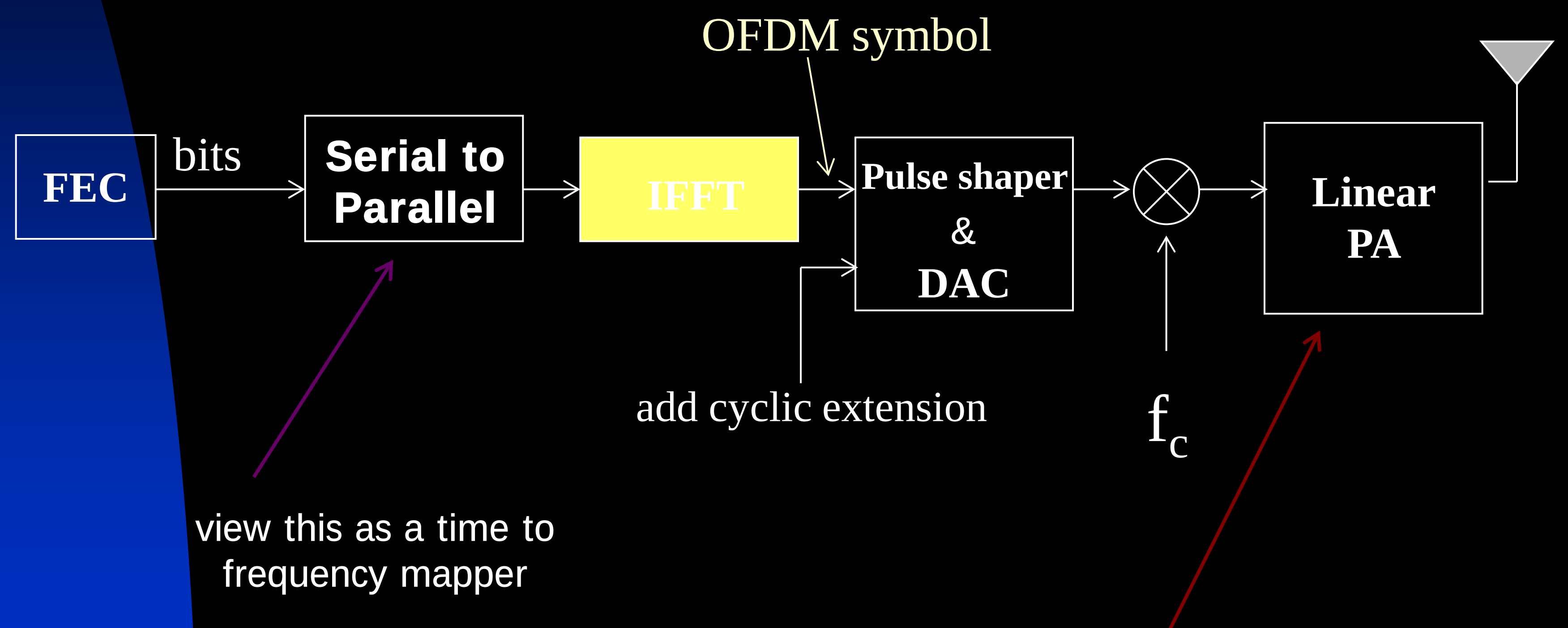
FDM → OFDM

- Frequency Division Multiplexing
- OFDM frequency dividing



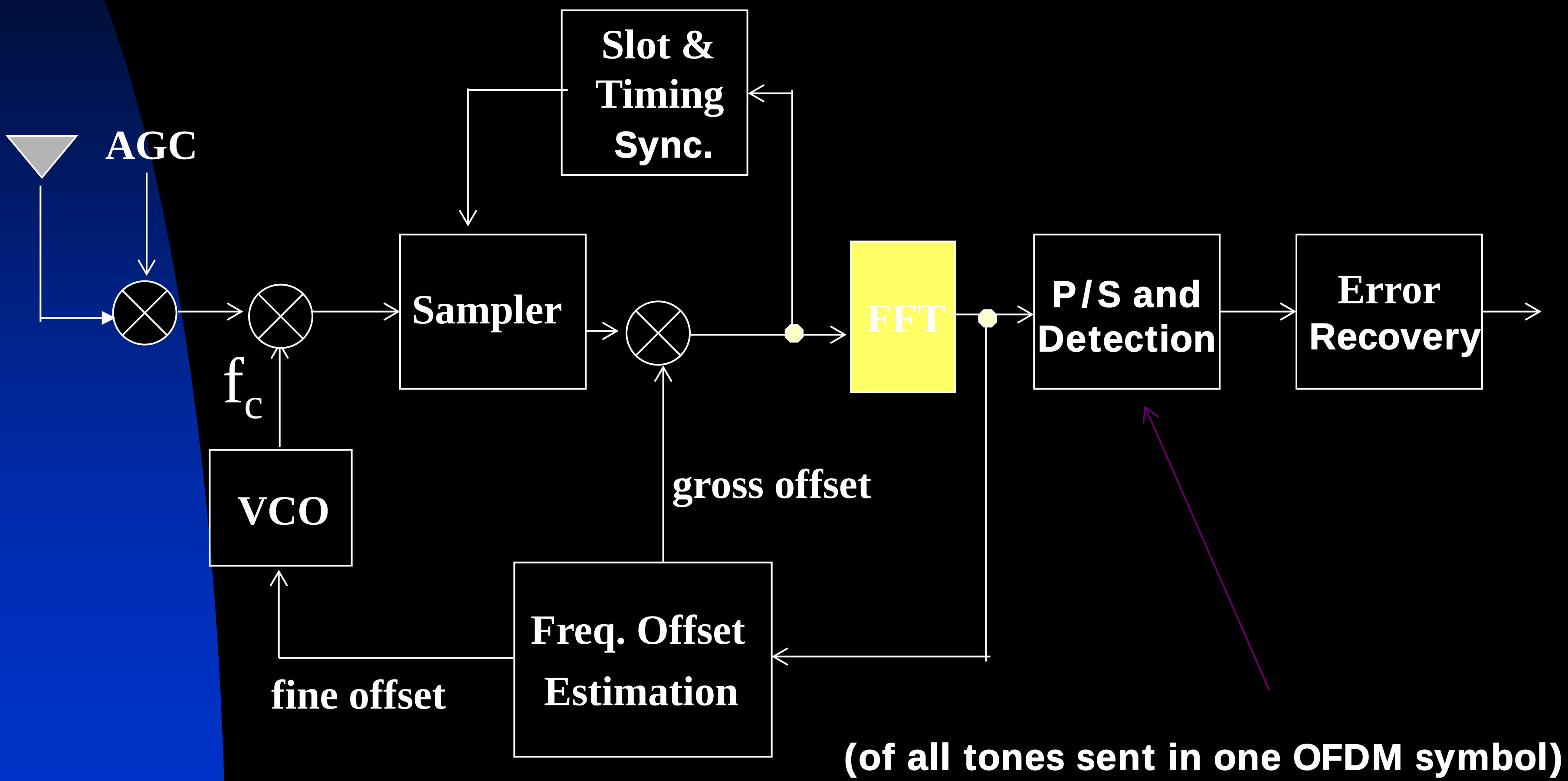
→ **EARN IN SPECTRAL EFFICIENCY**

Generic OFDM Transmitter

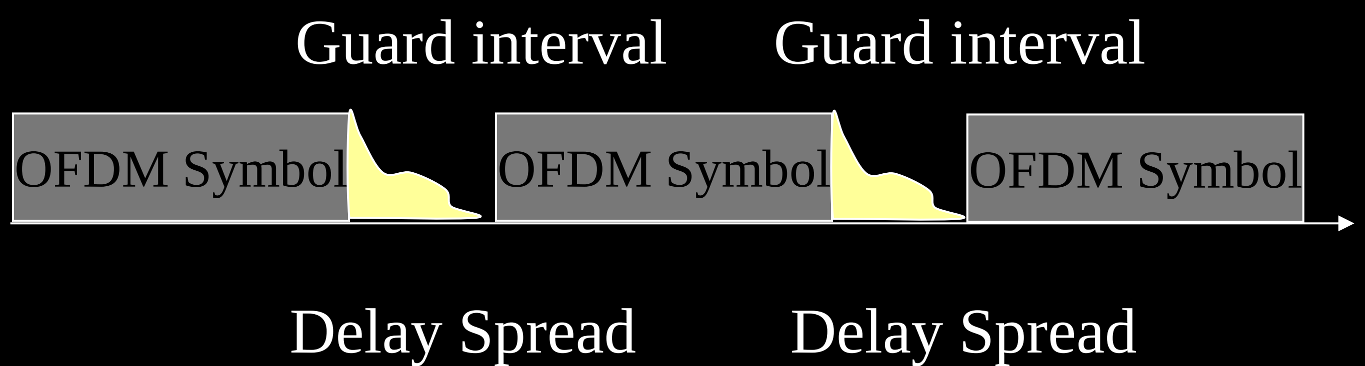


Complexity (cost) is transferred back from the digital to the analog domain!

Generic OFDM Receiver

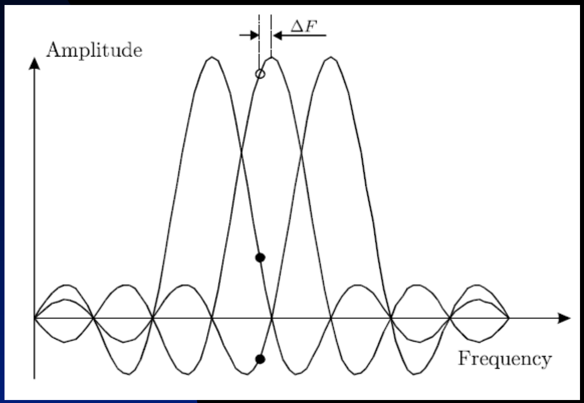


Guard intervals and intersymbol interference

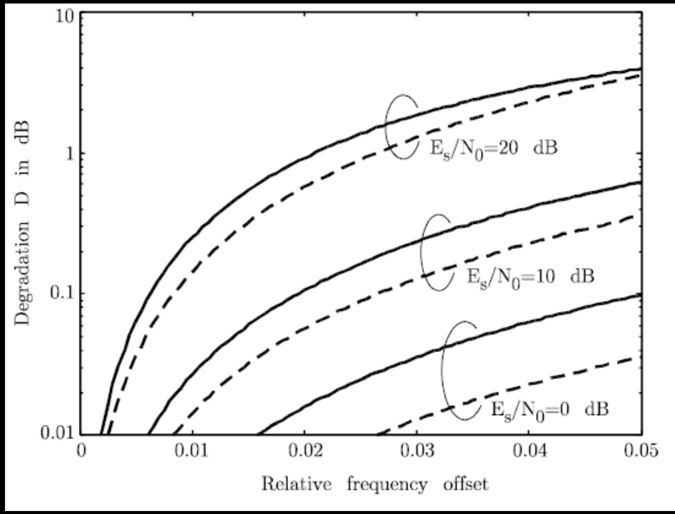


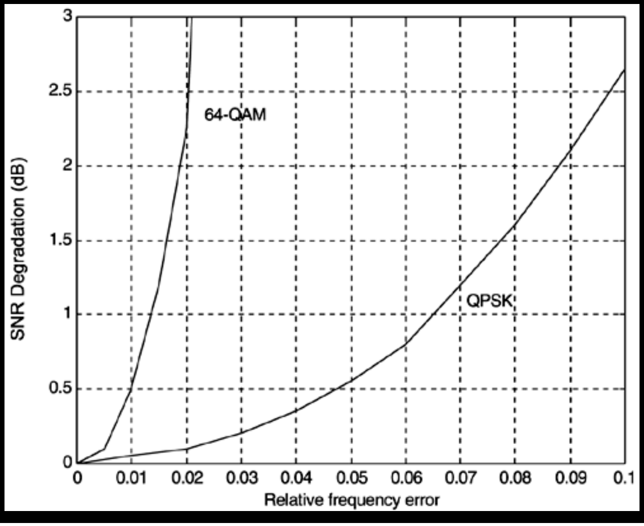
- If we space OFDM symbols by gaps at least as long as the delay spread, then there will be no intersymbol interference
- However, there will still be controllable interference within the symbol

Frequency Errors, Effects



—— Fading Channel
------ AWGN





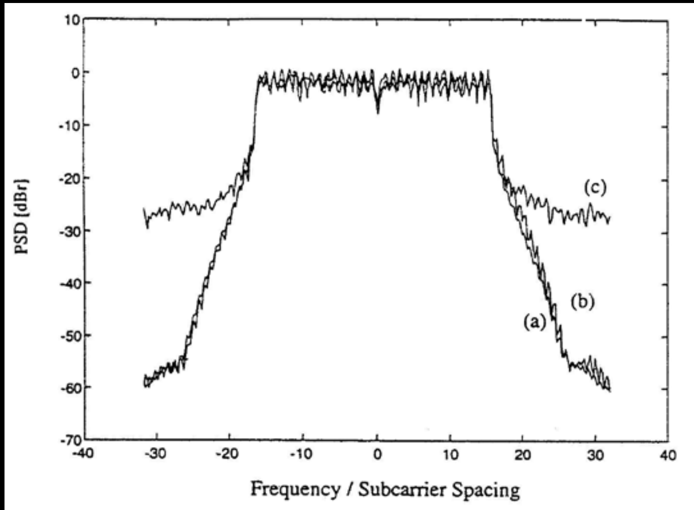
$$\Delta f = \frac{\Delta F}{W/N}$$

$$D\ (\text{dB}) \approx \frac{10}{3\ln 10}(\pi \Delta f)^2 \frac{E_s}{N_0} = \frac{10}{3\ln 10}\left(\pi \frac{N \cdot \Delta F}{W}\right)^2 \frac{E_s}{N_0}$$

Solution Techniques

- Clipping
  - Eliminate signals above a certain level or ratio
- Peak windowing
  - Filter peaks
- Linear block code
  - Select only those codewords with small PAPR
  - Can also provide error correction
- Peak Cancellation
  - Subtract signals from high peaks
  - Need to be similar bandwidth to limit out-of-band interfernce
- Symbol Scrambling

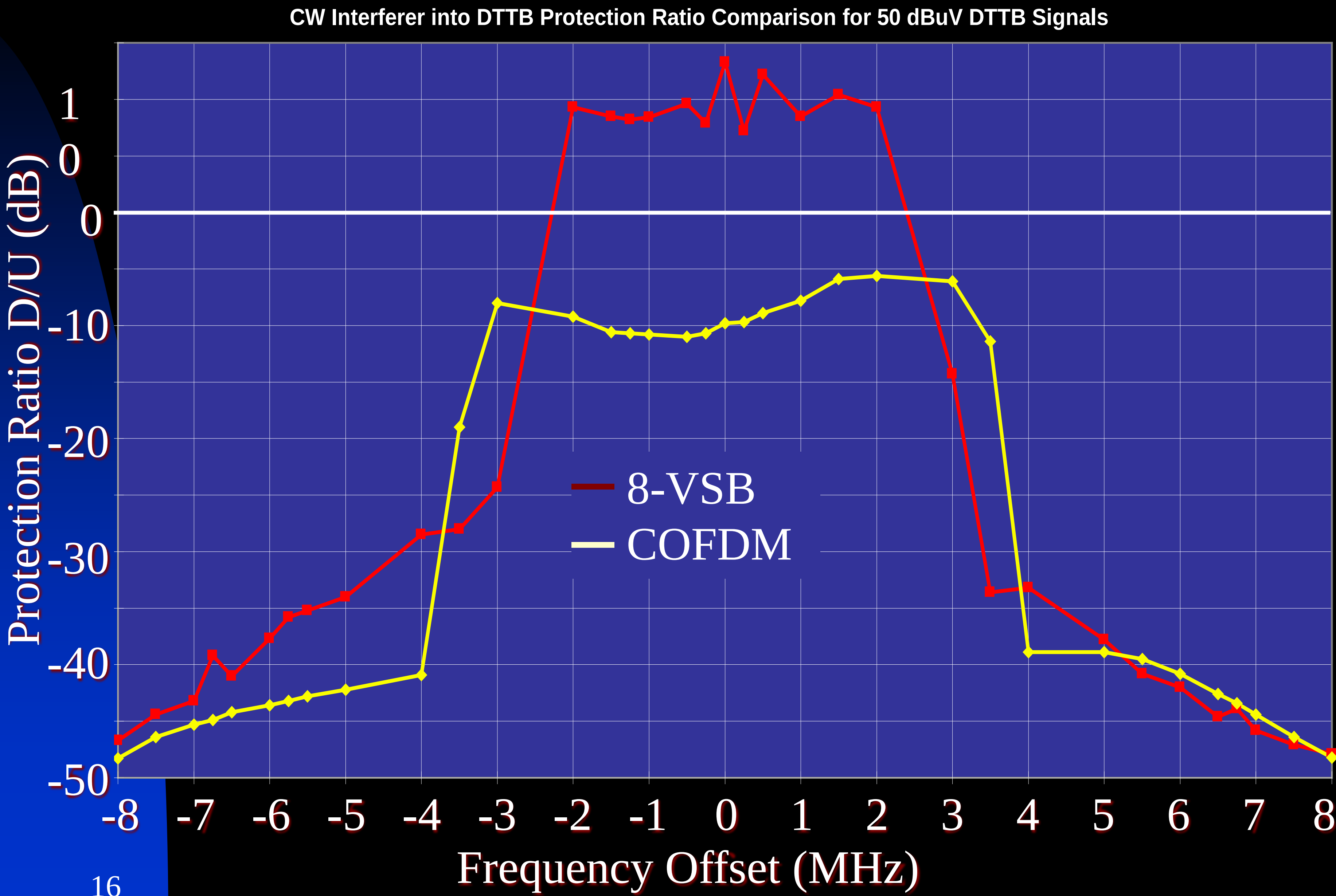
Peak Cancellation, Clipping, PAPR = 4dB



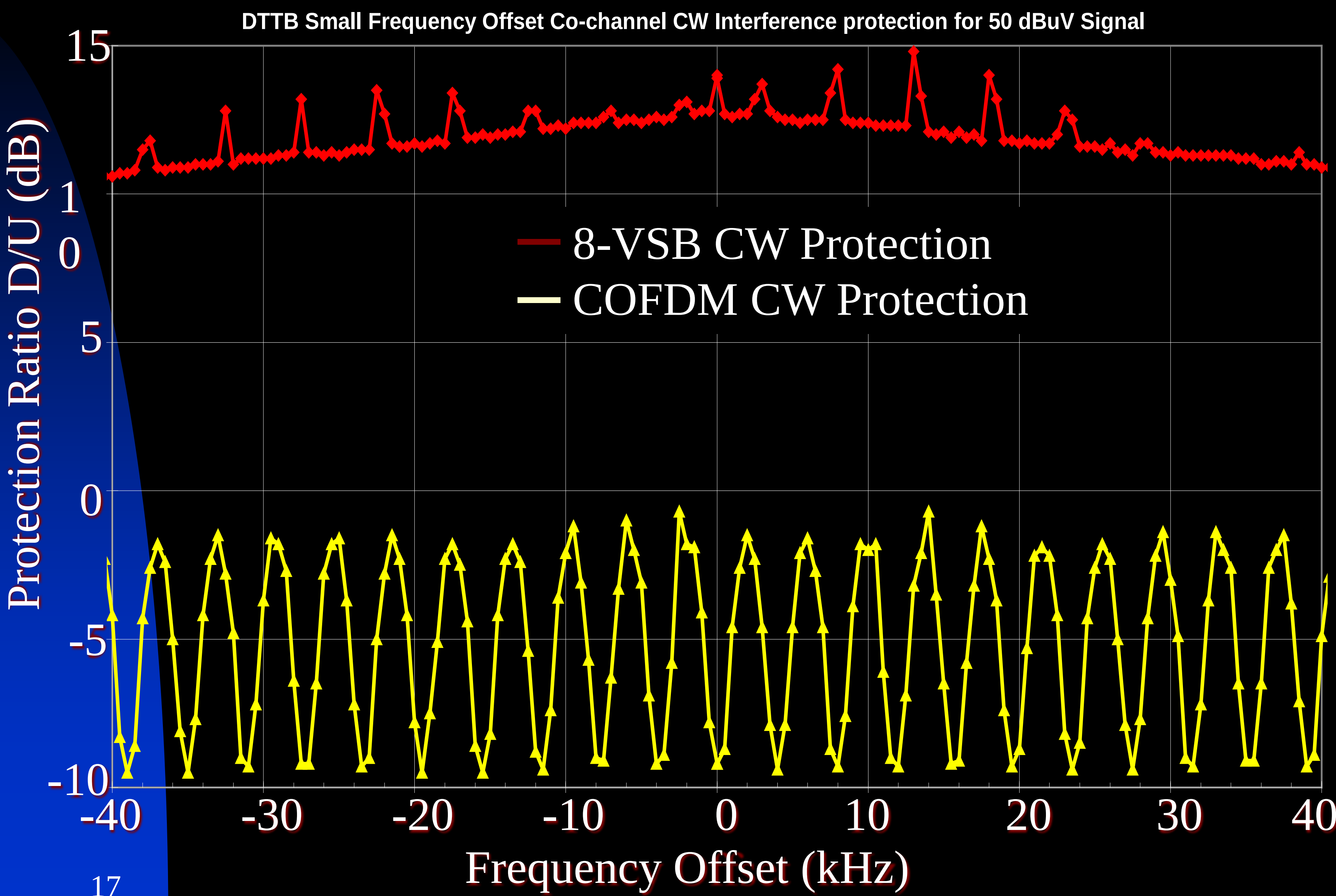
OFDM Summary

- OFDM overcomes even severe intersymbol interference through the use of the IFFT and a cyclic prefix.
- Limiting factor is frequency offset
  - Correctable via simple algorithm when preambles used
- Two key details of OFDM implementation are synchronization and management of the peak-to-average ratio.
- OFDM provides flexibility to a systems resource allocation
  - Permits exploitation of multi-user diversity

CW Protection into OFDM



CW into OFDM


DTTB Small Frequency Offset Co-channel CW Interference protection for 50 dBuV Signal
Protection Ratio D/U (dB)
15
10
5
0
-5
-10
-40
-30
-20
-10
0
10
20
30
40
Frequency Offset (kHz)
8-VSB CW Protection
COFDM CW Protection

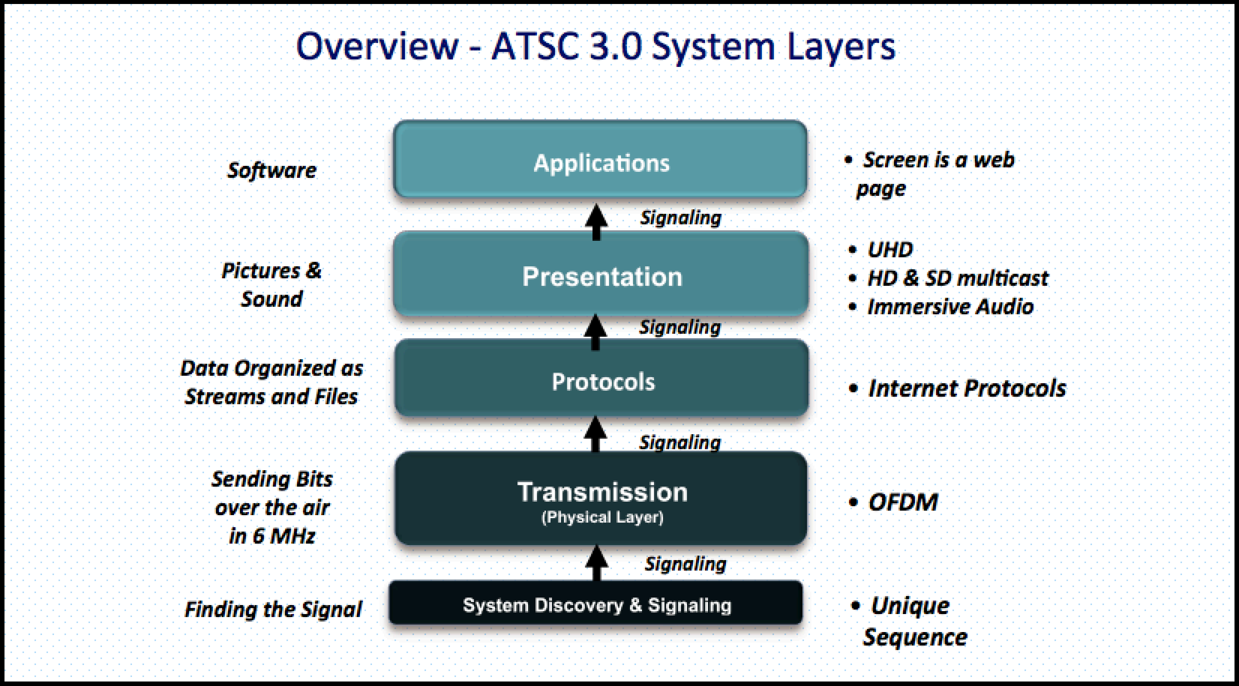
ATSC 3.0

- The Next New TV Broadcast Transmission Standard

- In Development Now

ATSC 3.0 BootStrap Approved

- Part of the Physical Layer
- The first of five sections to complete the standard



- ONE Media is a ‘Think Tank’ startup, currently focused on creating the “Next Generation Broadcast Platform” for the Broadcast Television industry.
- In concert with its joint venture partners, Sinclair Broadcast Group and Coherent Logix, ONE Media is a technology innovator at the forefront of developing industry standards and related technologies for Broadcast IP Network Services encompassing its flexible and enhanced vision for broadcasting.
- ONE Media has made significant contributions to ATSC 3.0 including:
  - **A/321 Synchronization and Discovery**
  - **A/322 Physical Layer (Sections)**

ONE Media Mission

Focus New Business Models

ONE Media

Broadcast TV Signals will Accommodate:

- 4K TV
- Immersive Audio
- Interactivity
- Multiscreen Viewing
- Mobile Devices and
- Hybrid Services
- Subscriber Information
- Audience Data
- IP Pipe

ATSC 3.0, ONE Media

(Elephant in the room: The Auction)

- Enhance Value of Broadcast Spectrum
- Broadcasters May Retain Channels
- Solidifies Our Spectrum Story

ONE Media Platform

- Definition of One Media Platform

- Relationship to ATSC 3.0

- Relationship To FCC Spectrum Efforts

Broadcast Industry Support

- The Need to Be Future-Proof

- Mobile Television Viewers

- New Revenue Streams

Conversion Costs

- New Exciter Needed

- Repacking as Well?

- Some Funds To Be Available

SFN Costs

- SFN is Always An Option

- Why Use An SFN?
  - DMA Extension
  - Fill-In Due to IX
  - Hyper Local Zoning

Transition

- No Second Channel This Time

- “Designated” Host Station

- First Are Gateway Devices

Mobility

- The Need to Be Future-Proof

- TV Everywhere is not OTA

- Need Alternative to Pay

Business Case

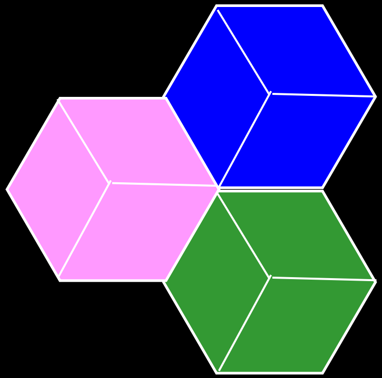
- Too Speculative Now?

- Capture The Millenials!

- Broadcast Enhancements

Sectorized Antennas

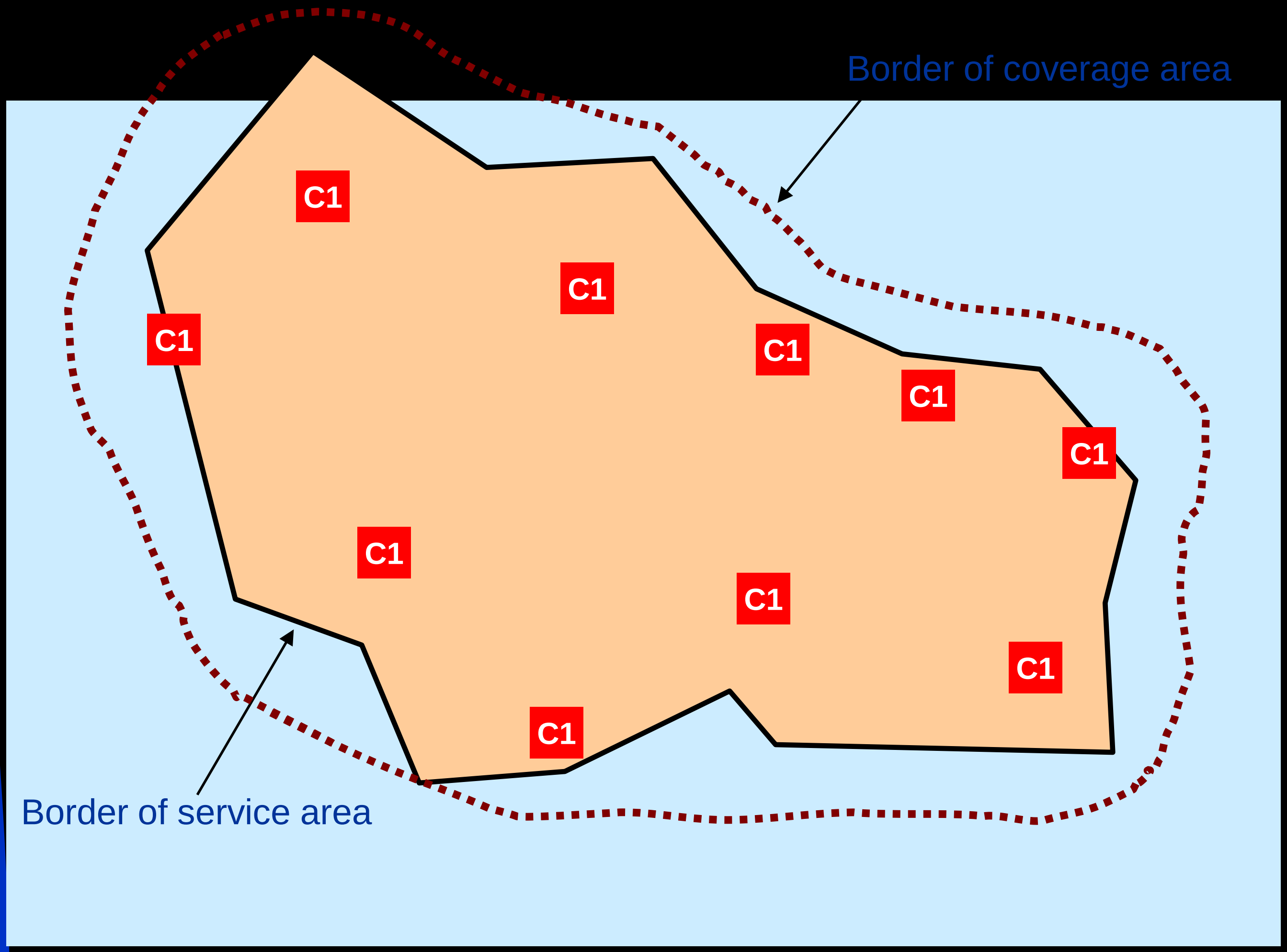
- Interference reduction by using sectorized antennas.

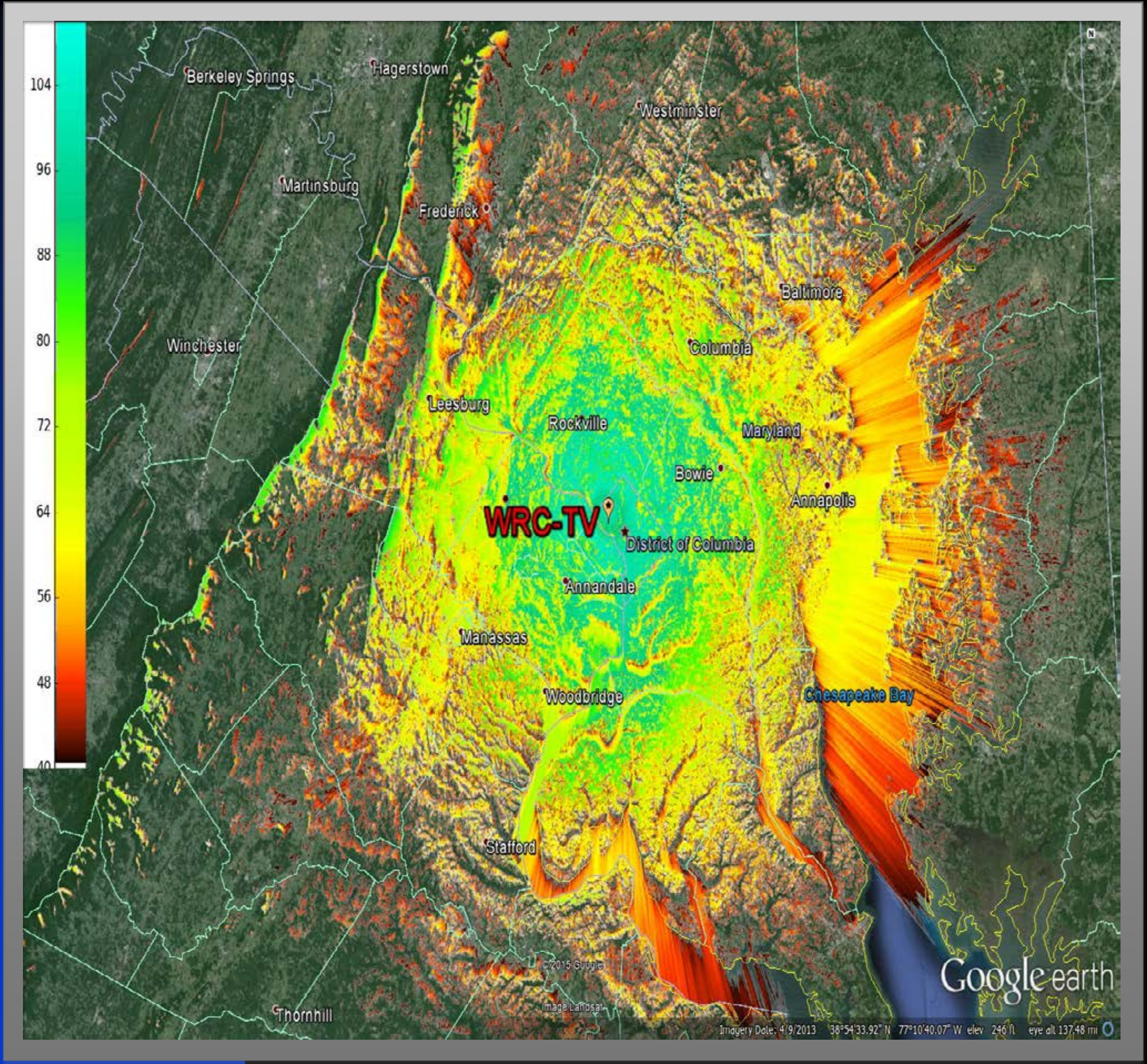


Network structures and configurations

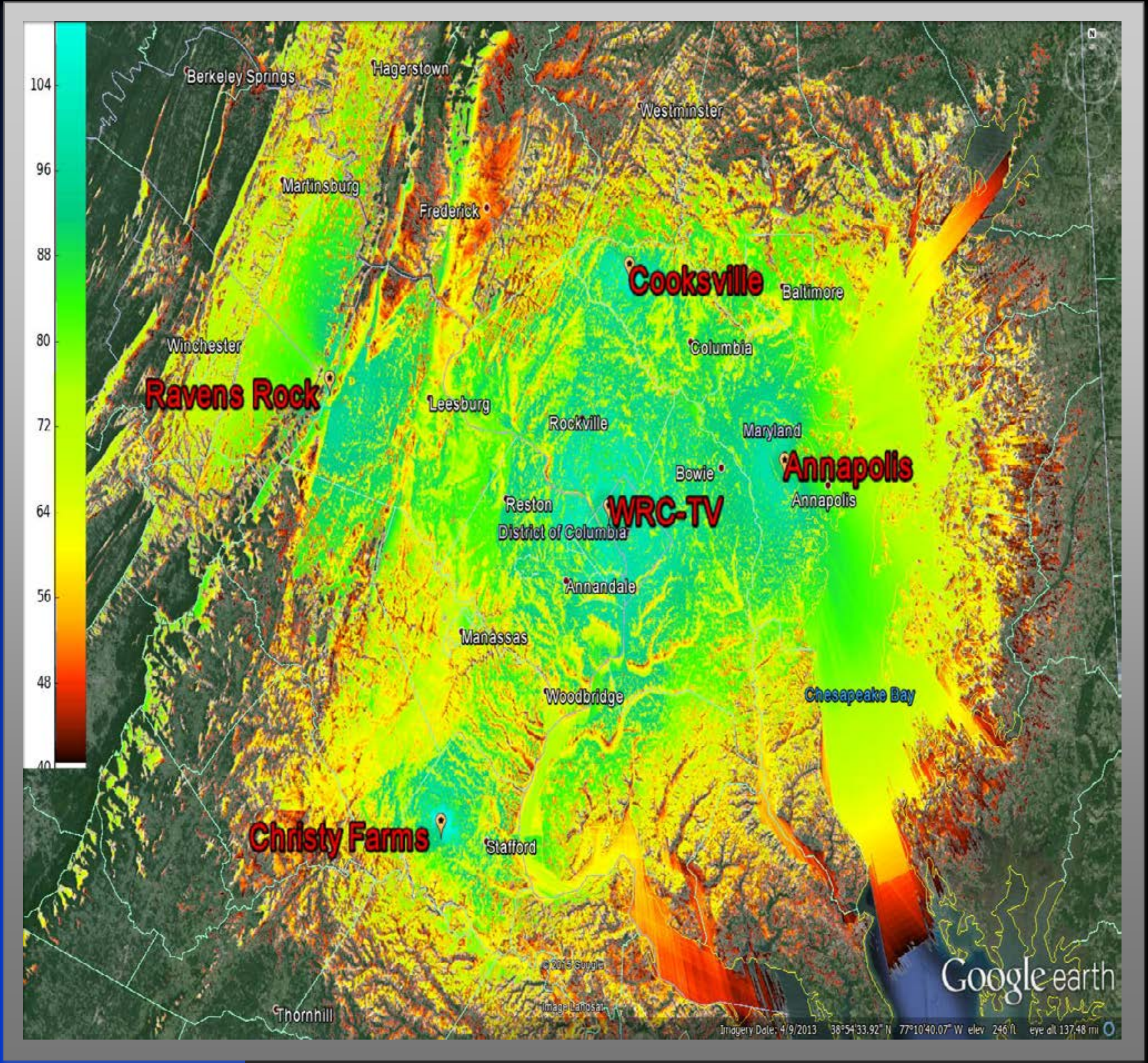
- multi-frequency networks (MFN) allow the same or different programs to be carried by individual transmitters using different frequencies
- single frequency networks (SFN): coverage is provided by multiple transmitters operating on the same frequency and carrying the same programs

Single Frequency Network

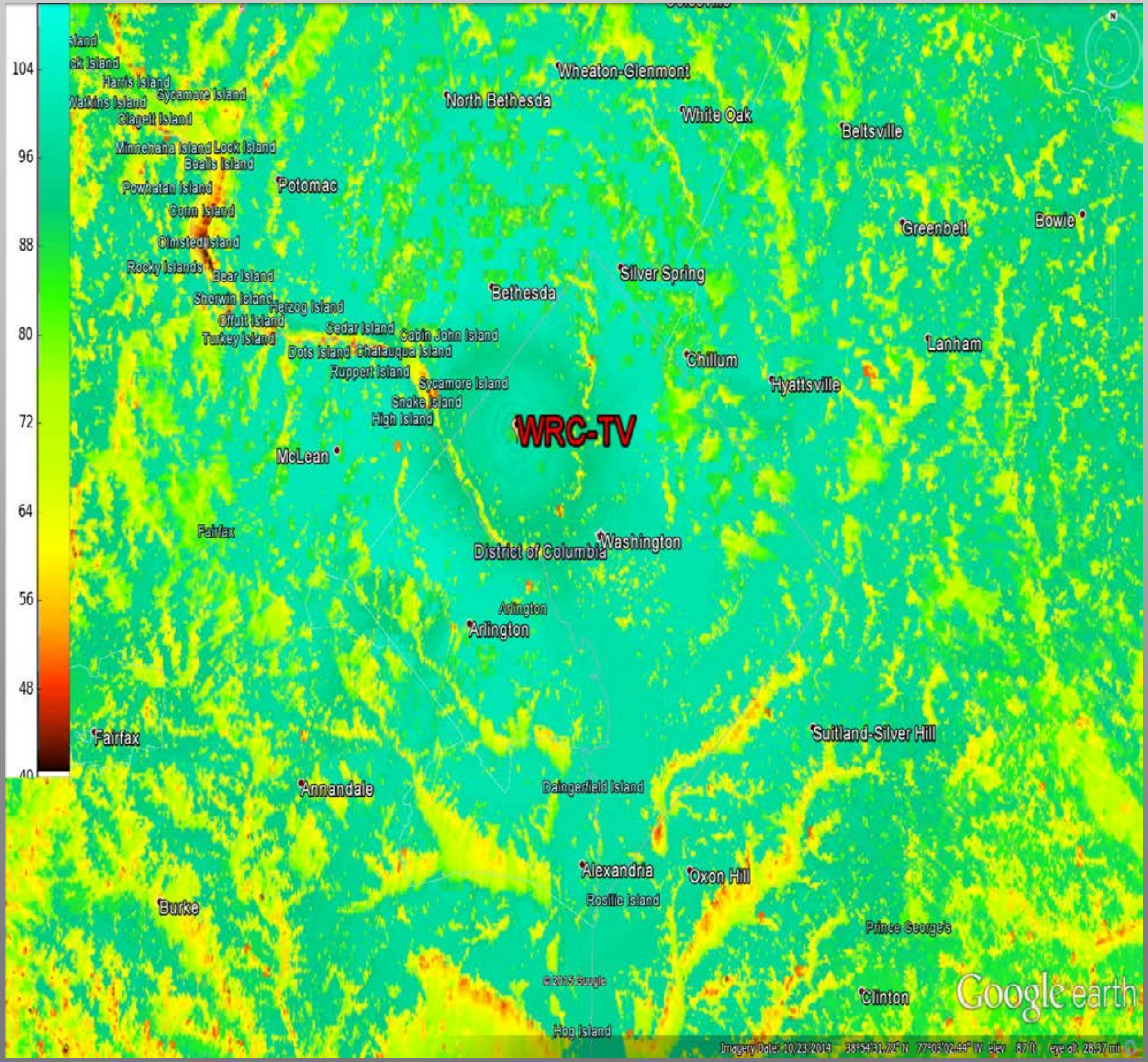




DC – WRC-DT (ATSC 3.0 1 MW ERP on Ch. 36)



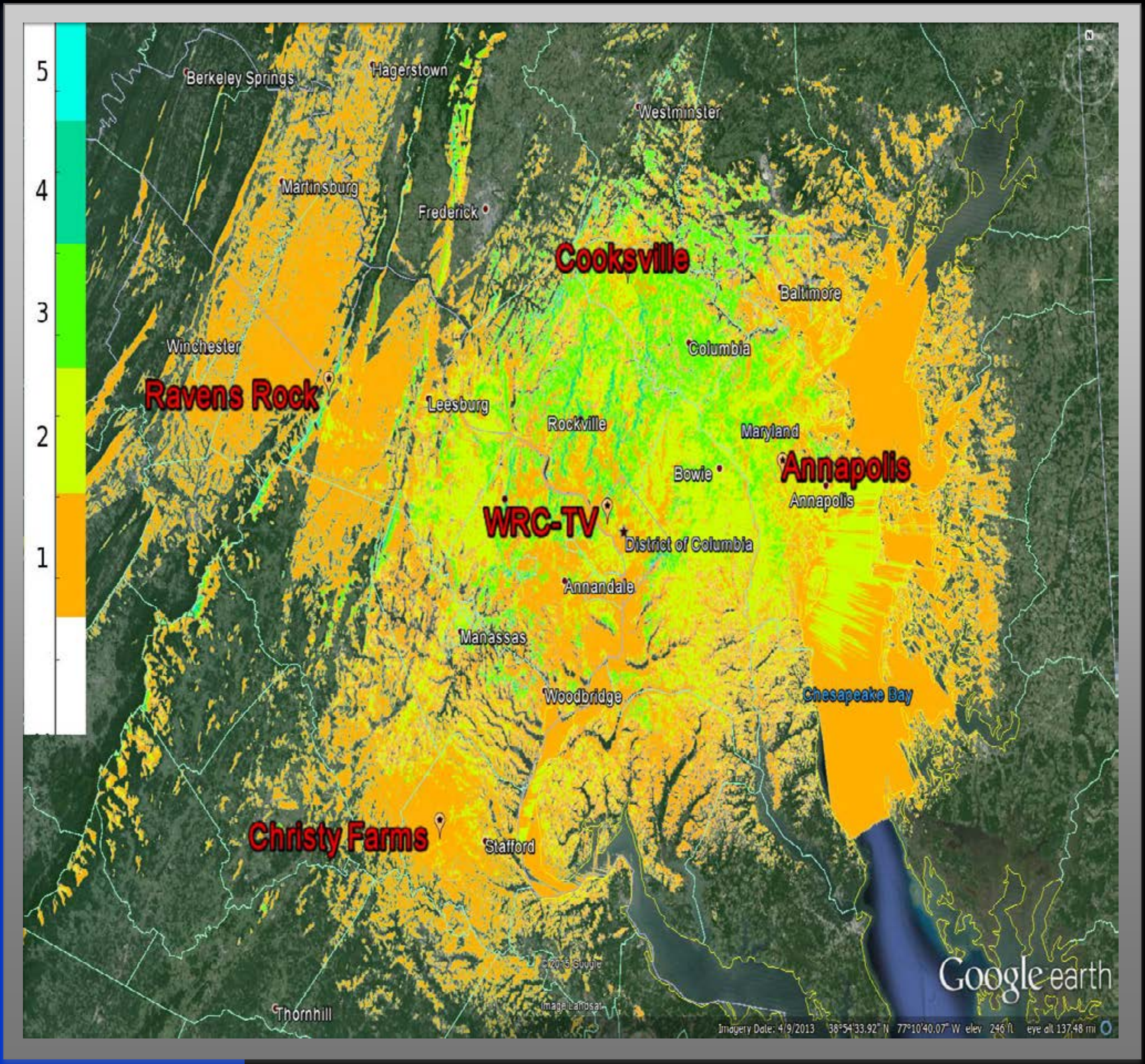
DC – Adding SFN RSS Combined



DC – Combined (closeup)

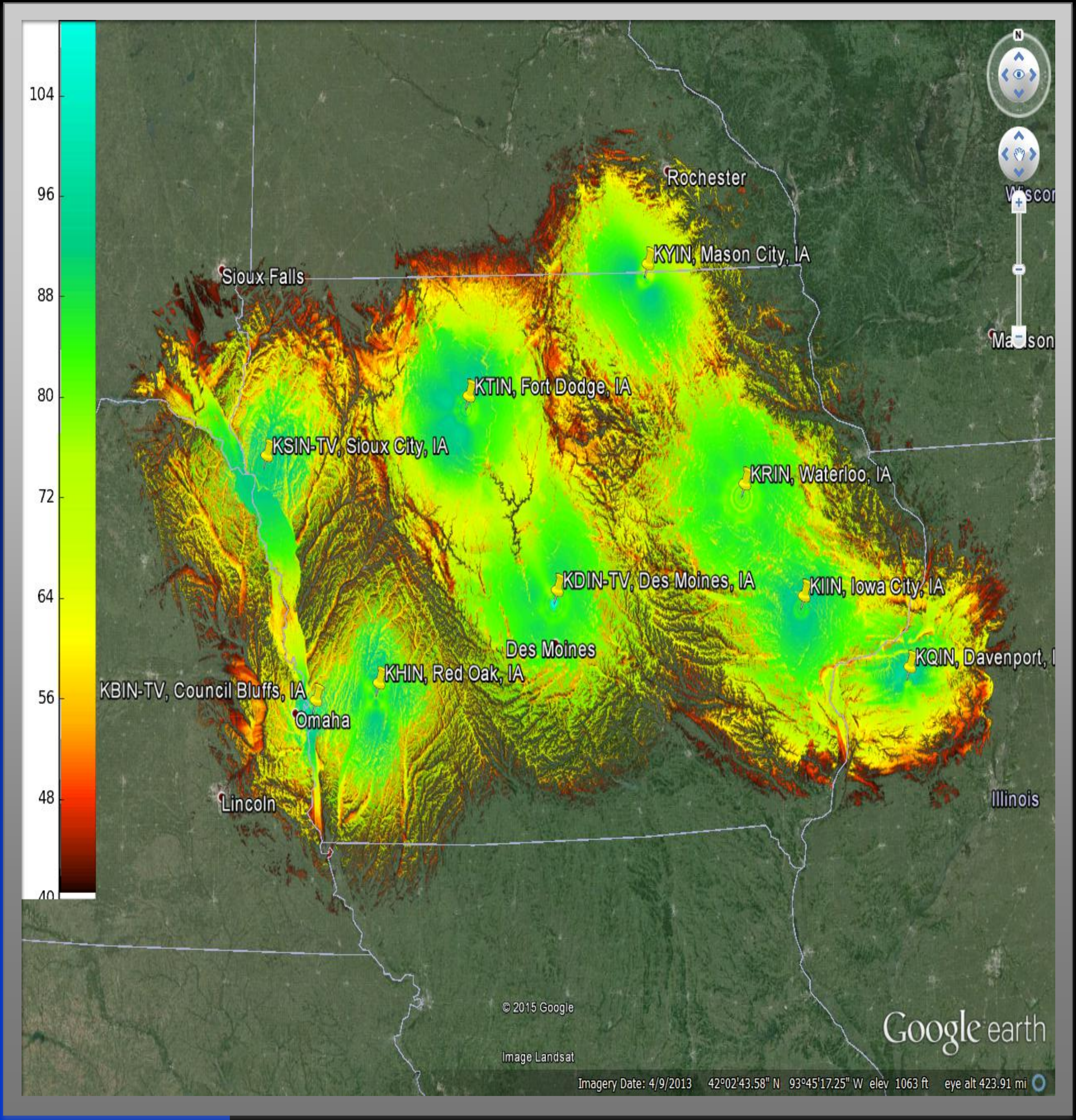
Combined Service → More People

Condition	80 dBµV/m pop
Single transmitter (DC)	2,819,869
Combined (5 transmitters)	4,596,775
Percent gain:	63%
Gain where WRC site >= 40 dBµV/m	4,439,293
Percent gain:	57%
Population served by 2 sites	246,442
Population served by 3 sites	1,497,278
Population served by 4 sites	1,763,638
Population served by 5 sites	1,017,223



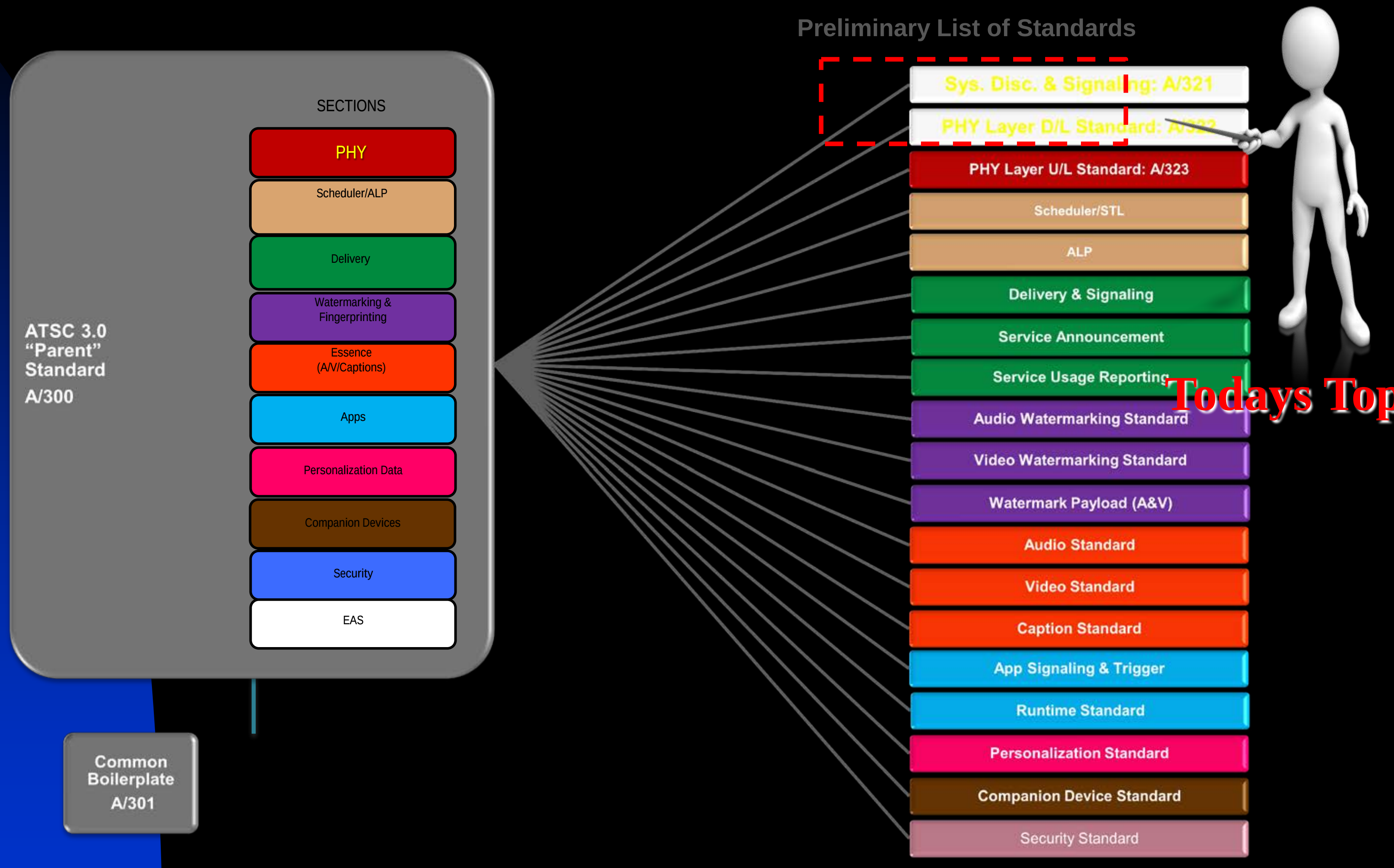
DC – Number of Sites

Iowa - SFN

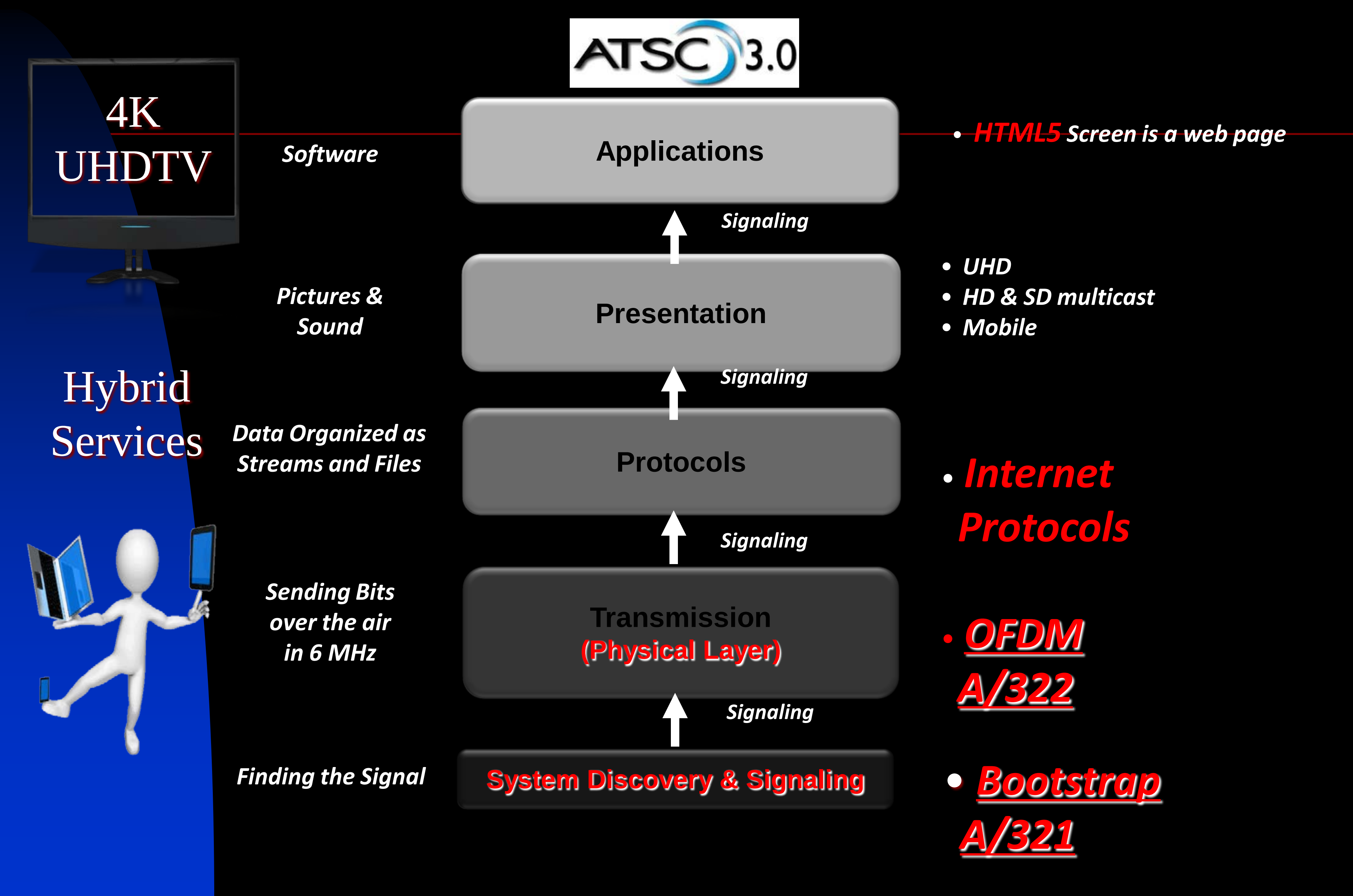


Example: Iowa SFN Ch. 36
L/R 95/90
4m Rx. Ht.

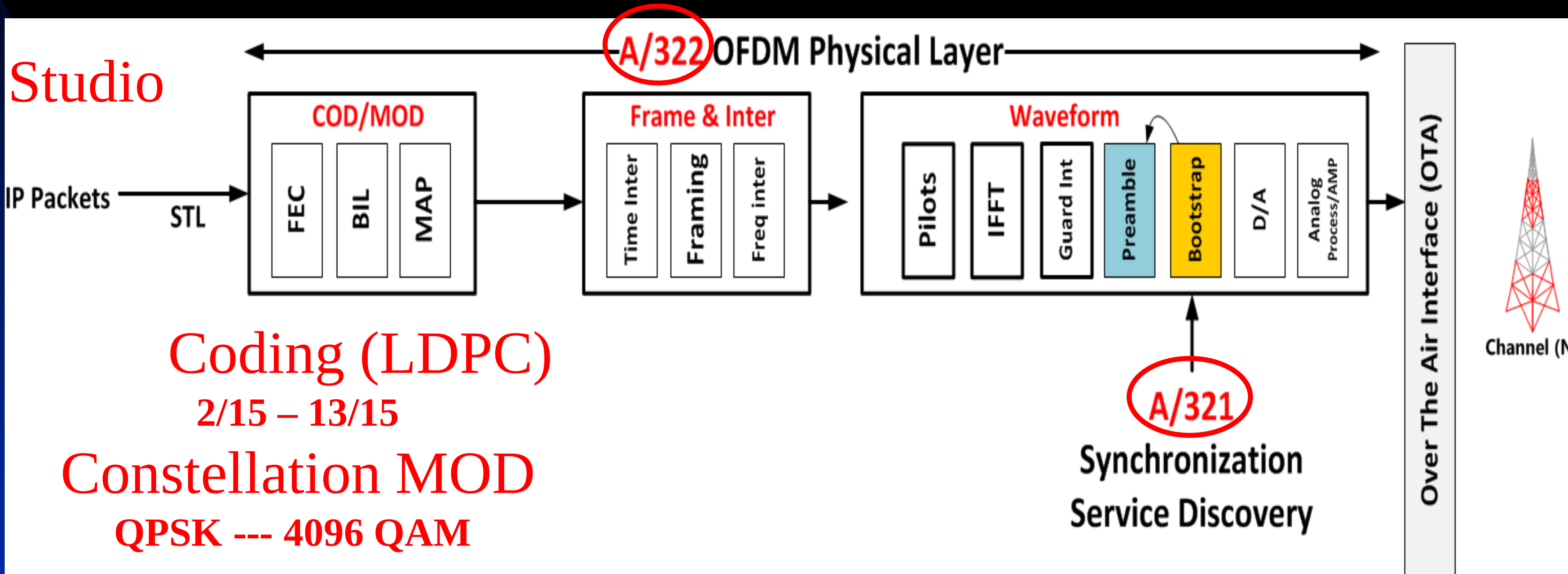
ATSC 3.0 Document Structure



Overview - ATSC 3.0 System Layers

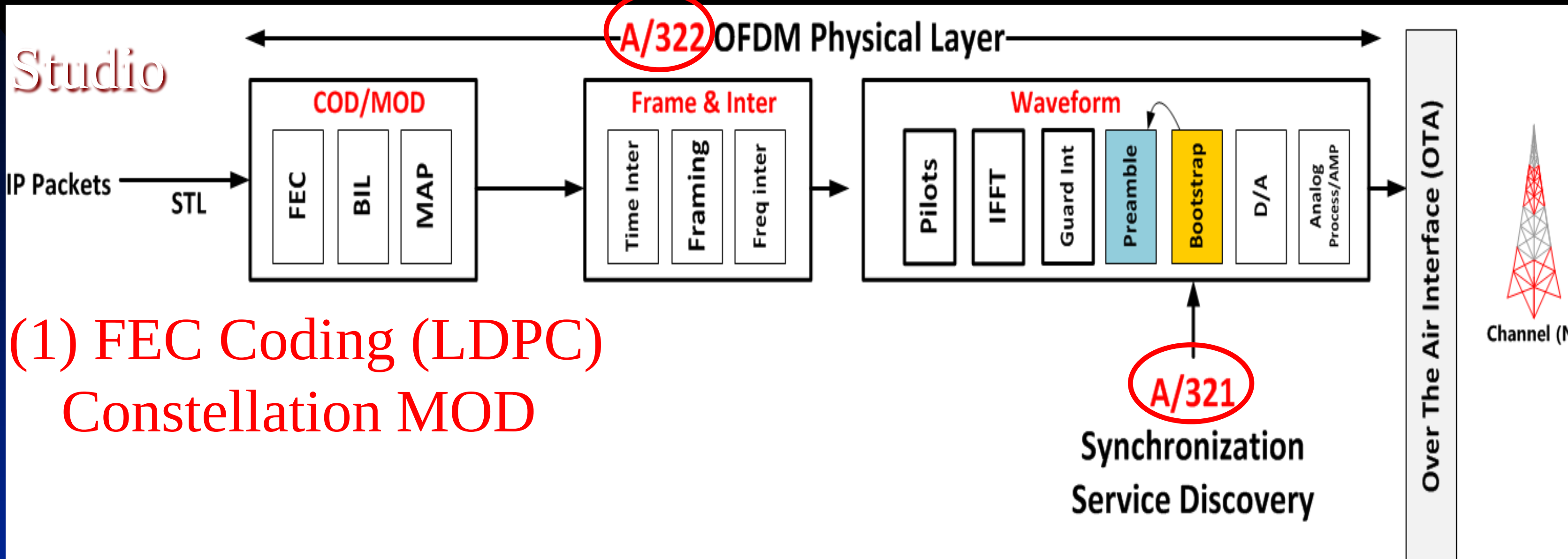


(3) Major Blocks Physical Layer



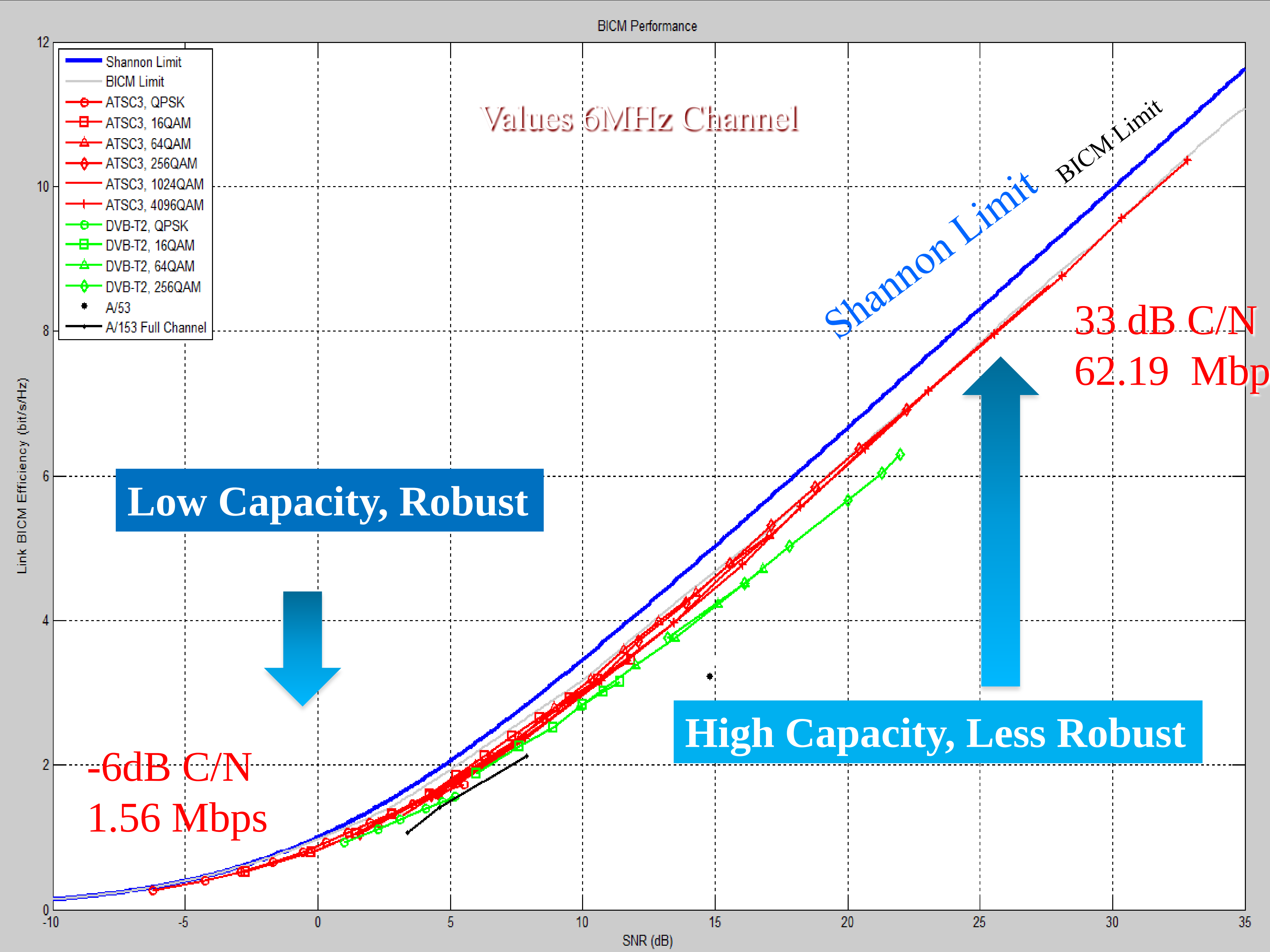
Time /Frequency
Interleaving
Cell Multiplexing

Major Blocks Physical Layer

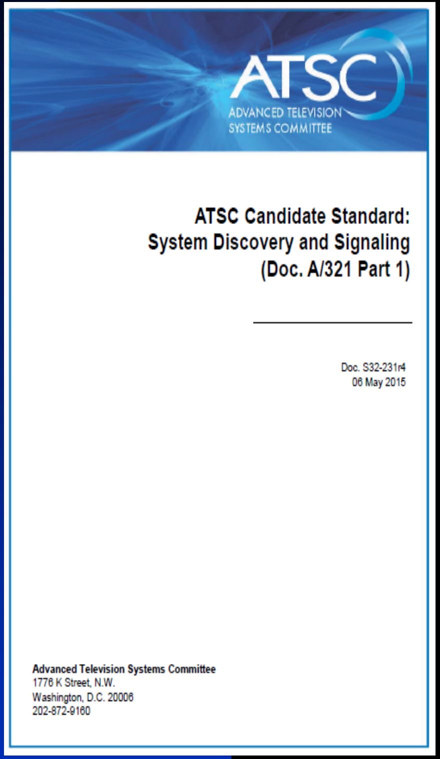


(1) FEC Coding (LDPC)
Constellation MOD

Highly optimized and approaching Shannon Limit


BICM Performance
Shannon Limit
BICM Limit
ATSC3, QPSK
ATSC3, 16QAM
ATSC3, 64QAM
ATSC3, 256QAM
ATSC3, 1024QAM
ATSC3, 4096QAM
DVB-T2, QPSK
DVB-T2, 16QAM
DVB-T2, 64QAM
DVB-T2, 256QAM
A/53
A/153 Full Channel
Values 6MHz Channel
Shannon Limit
BICM Limit
33 dB C/N
62.19 Mbp
Low Capacity, Robust
High Capacity, Less Robust
-6dB C/N
1.56 Mbps
Link BICM Efficiency (bit/s/Hz)
SNR (dB)
0
2
4
6
8
10
12
-10
-5
0
5
10
15
20
25
30
35

A/321 Part 1: ATSC Candidate Standard: System Discovery and Signaling


ATSC
ADVANCED TELEVISION
SYSTEMS COMMITTEE

ATSC Candidate Standard:
System Discovery and Signaling
(Doc. A/321 Part 1)

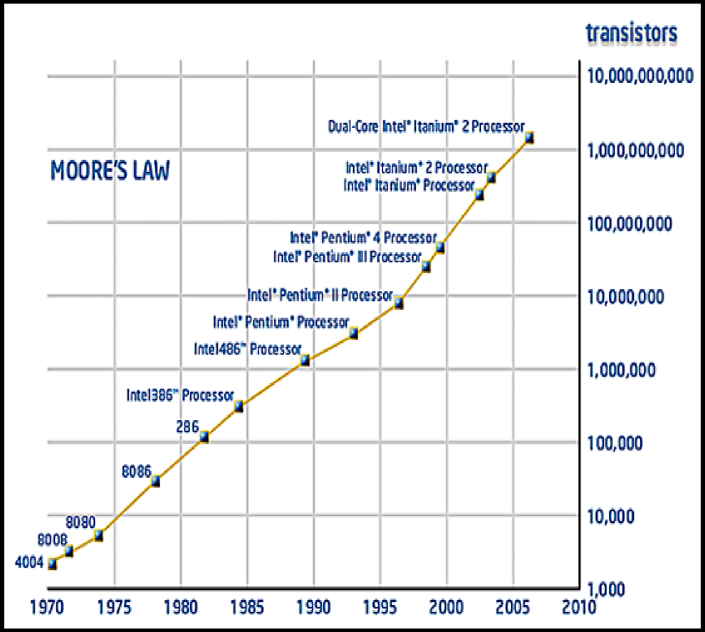
Doc. S32-231r4
06 May 2015

Advanced Television Systems Committee
1776 K Street, N.W.
Washington, D.C. 20006
202-872-9160

- This document describes the system discovery and signaling architecture for the ATSC 3.0 physical layer. Broadcasters anticipate providing multiple wireless-based services, in addition to just broadcast television, in the future. Such services may be time-multiplexed together within a single RF channel.
- The bootstrap provides a universal entry point into a broadcast waveform. The bootstrap employs a fixed configuration (e.g., sampling rate, signal bandwidth, subcarrier spacing, time-domain structure) known to all receiver devices and carries information to enable processing and decoding the wireless service associated with a detected bootstrap.
- This new capability ensures that broadcast spectrum can be adapted to carry new services and/or waveforms for public interest to continue to be served in the future.

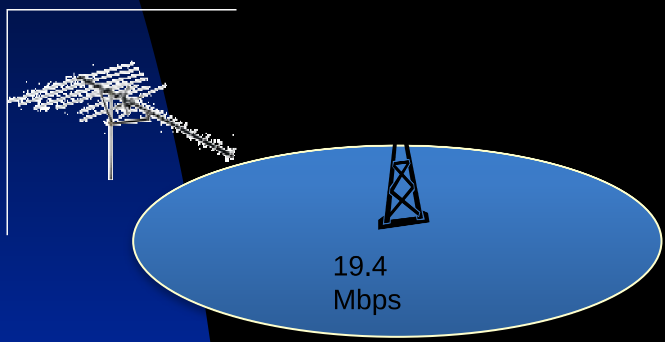
Extensibility/Evolution

- ATSC 3.0 meant to last, but technology advances rapidly
- Methods to gracefully evolve must be in the core
  - Signal when a layer or components of a layer evolves
  - Signal minor version changes and updates to waveform
  - Signal major version changes and updates to waveform
- Goal is to avoid disruptive technology transitions
  - Enable graceful transition



Transmission

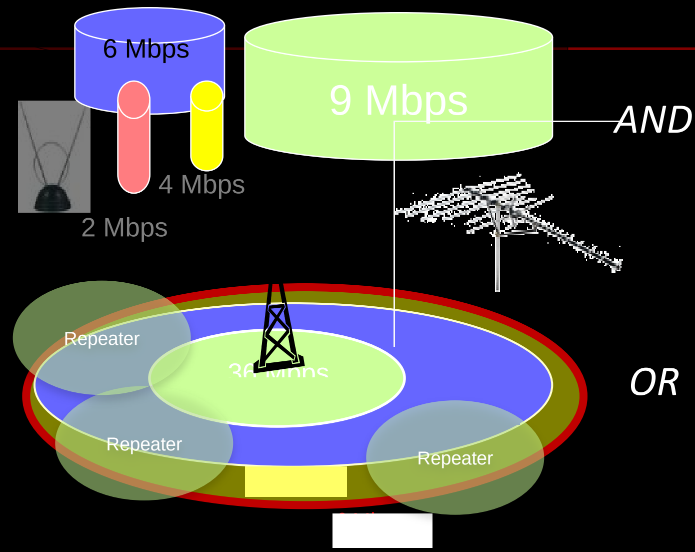
ATSC 1.0



8-VSB

- One bit rate – 19.39 Mbps
- One coverage area – 15 db CNR (rooftop)
- Service flexibility – HDTV, multicast, data

ATSC 3.0



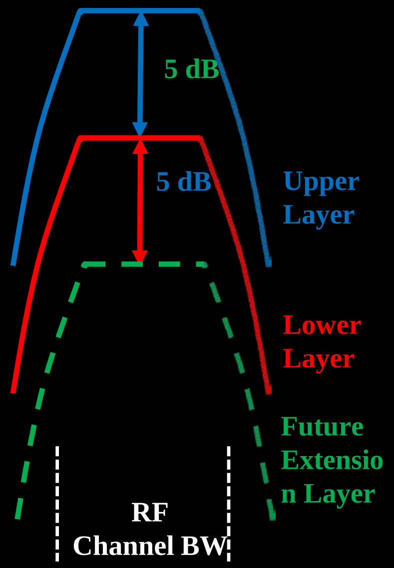
OFDM with variable-rate LDPC

- More bits/Hz – spectrum efficiency near theoretical limit
- Flexible bit rate & coverage area choices
- Multiple simultaneous “bit pipes” – different choices for different broadcast services
  - Physical Layer Pipes (time)
  - Layer Division Multiplexing (power)
  - Channel Bonding

More Bits To More Places

Layered Division Multiplexing (LDM)

- LDM is a new transmission scheme that uses **spectrum overlay technology** to super-impose multiple physical layer data streams with different power levels, error correction codes and modulations for different services and reception environments;



LDM overlay spectrum

Benefits IP transport Layer

  - Take advantage of evolution speed of Internet
- Broadcast & Broadband as peer delivery mechanisms
  - Enables new types of hybrid services
  - Ability to seamlessly incorporate niche content
- Enable new business models
  - Localized Insertion
    - Ads or other content
    - Allows revenue model for broadcasters that has been available to cable or IPTV operators

Presentation

Better Pictures & Sound and/or More Services

ATSC 1.0

Standard Dynamic Range and Color
100-nit color grading, Rec. 709 color, 8

- Allows HDTV & SD multicast
  - HDTV – MPEG-2 (12 – 18 Mbps)
  - SDTV – MPEG-2 (3 – 5 Mbps)
  - 5.1 Dolby Digital surround sound

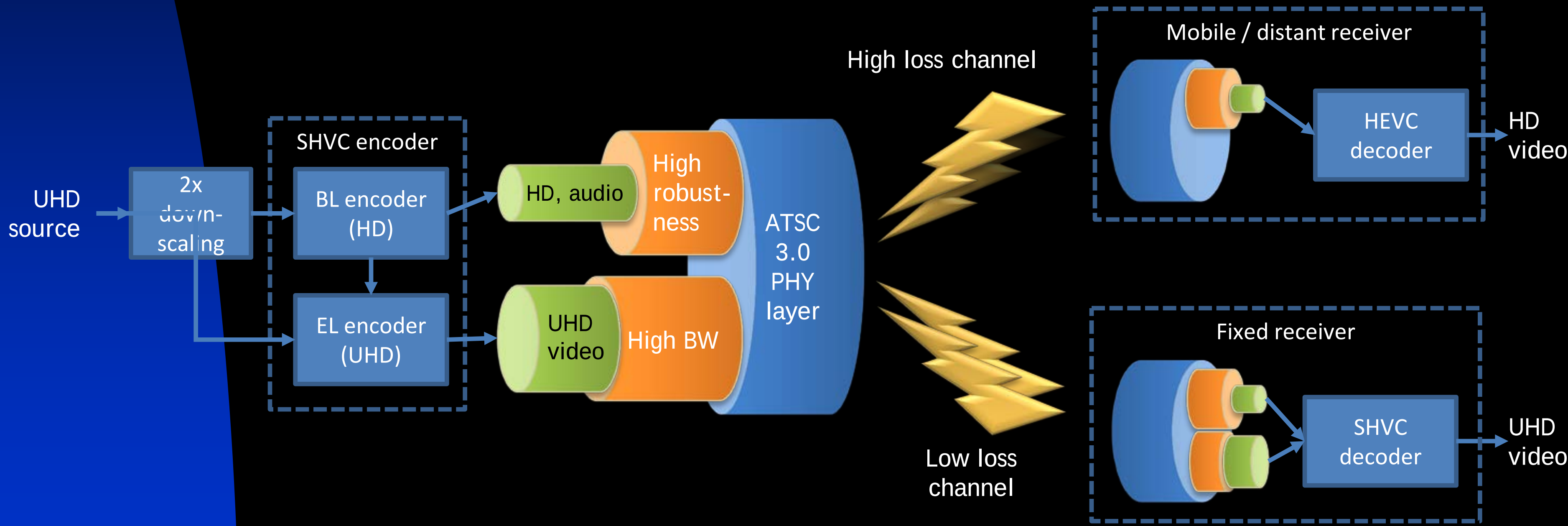
ATSC 3.0

h Dynamic Range and Wide Color Gamut
1000-nit color grading, Rec. 2020 color, 10 bits/pixel

- Allows UHD and/or HD multicast
  - Super-4k – HEVC (18 – 30 Mbps)
  - Super-HD – HEVC (8 – 12 Mbps)
  - HD – HEVC (3 – 8 Mbps)
  - SD – HEVC (1 – 2 Mbps)
  - Immersive Audio

estimated bit rates

SHVC: Layered Video Coding



Applications

Internet Experience
Personalized & Dynamic

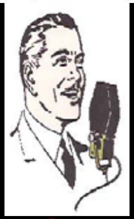
ATSC 1.0

ATSC 3.0

Audio: Personalization

- Choose language


- Choose commentary




- Address impairments with description and improved intelligibility
- Normalize loudness of all content

  - Contour dynamic range




Immersive, Enhanced Surround Sound

ATSC 3.0 Supports Multiple Platforms!

In Summary

ATSC 3.0

- Will not be backward compatible to the legacy system
- UHDTV & Immersive Audio
- Personalization
- Robust delivery to multiple platforms
- Supports viability and new business models of broadcasters
- Flexible to accommodate future improvements and developments

Coming 2016-2017