ATSC 3.0 – Characteristics and Transmission Requirements

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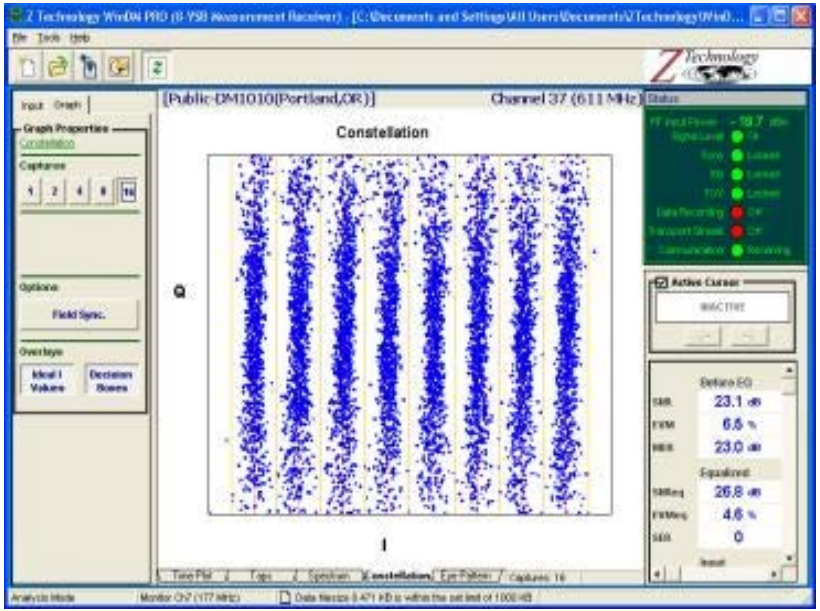
Discussion Points

- Differences between ATSC 1.0 & ATSC 3.0
  - Modulation 8-VSB vs. OFDM
- How much ATSC 3.0 power is needed?
  - Peak-to-Average Ratio (PAR / PAPR)
  - V-Pol
- RF plant considerations for 3.0
  - Transmitter, Mask Filter, Test Load, RF Line, Antenna
- Transition scenarios for ATSC 3.0 migration
- Planning ahead - What can I do right now?

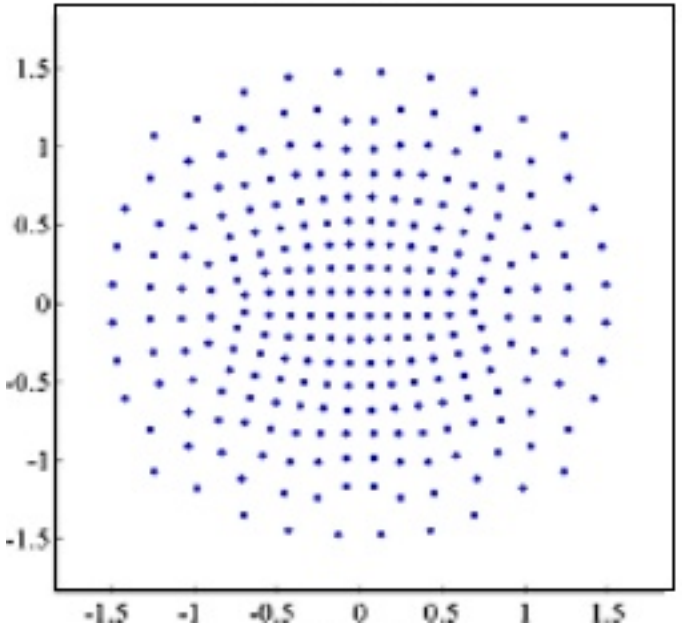
Differences Between ATSC 1.0 & 3.0

8-VSB



ATSC-1.0

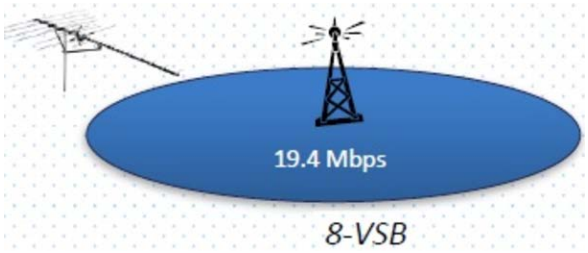
Non-uniform 256 QAM CR 13/15



ATSC-3.0
(one of many constellations)

ATSC 1.0, 2.0 & 3.0

ATSC 1.0

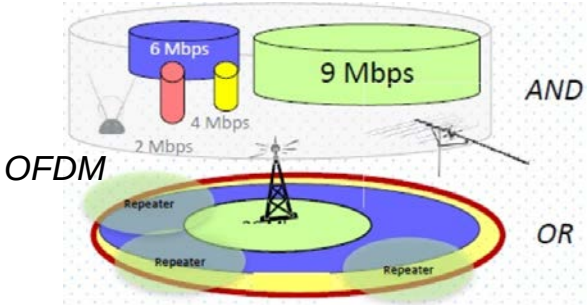


- It uses 8VSB modulation
- Supports one bit rate of 19.39 Mbps
- Provides coverage with 15dB CNR at rooftop
- Supports HDTV, multicast and data transmission.
- Here both TV and internet were separately served to users or customers.
- Allows HD and SD multicast

ATSC 2.0

- Backward compatible with ATSC 1.0
- Allows interactive and hybrid TV using internet protocols
- Advanced Codecs: AVC (A/72), Dolby E-AC-3 (A/53-6 & A/52), MPEG HE AAC v2, and DTS-HD
- Supports advertisements
  Video on demand
- Allows storage of non real-time content

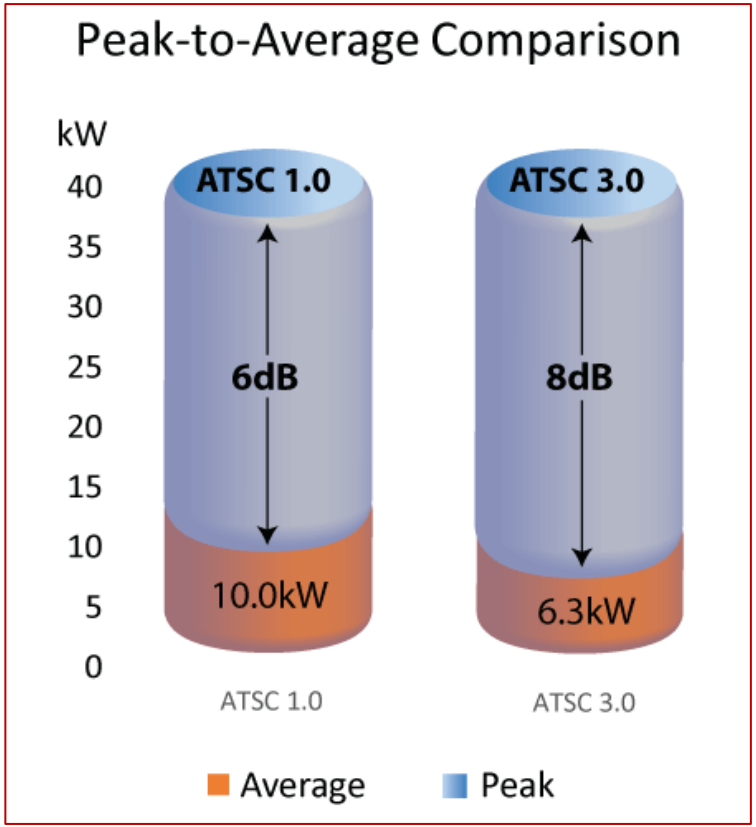
ATSC 3.0



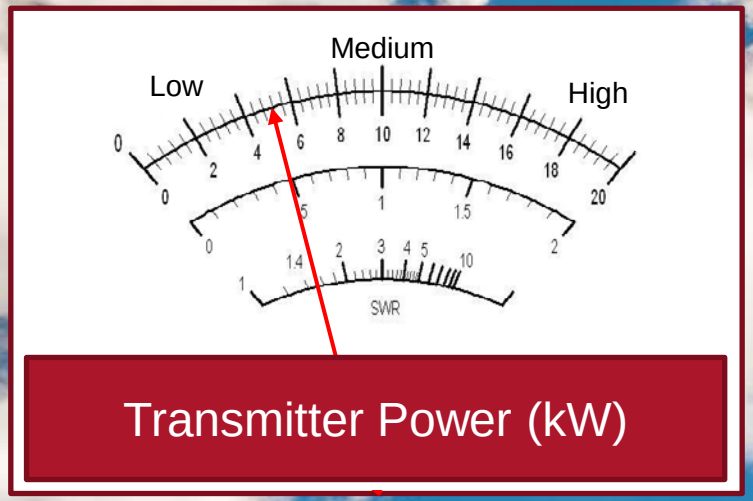
- Broadband and broadcasting merged
- More bits/Hz = better spectrum efficiency
- Flexible bit rates and coverage areas
- Multiple simultaneous bit pipes with different choices for different broadcast services viz. physical layer pipes (time), layered division multiplexing (power) and channel bonding
- Allows UHD and/or HD multicast
- Higher data rates up to and beyond 36Mbps
- Supports 4K TV (3840 X 2160 / 60 fps

Key Differences 1.0 ⇨ 3.0

- A (very) quick review:
  - ATSC 1.0 uses **8-VSB** and a fixed payload of 19.39Mb/s
  - ATSC 3.0 uses **OFDM** and is extremely flexible with multiple modulation settings. Payloads from a few Mb/s to over 36Mb/s
  - ATSC 1.0 has a *transmitted* PAR of approx. **6.0dB**
  - ATSC 3.0 has a *transmitted* PAR of approx. **8.0dB**



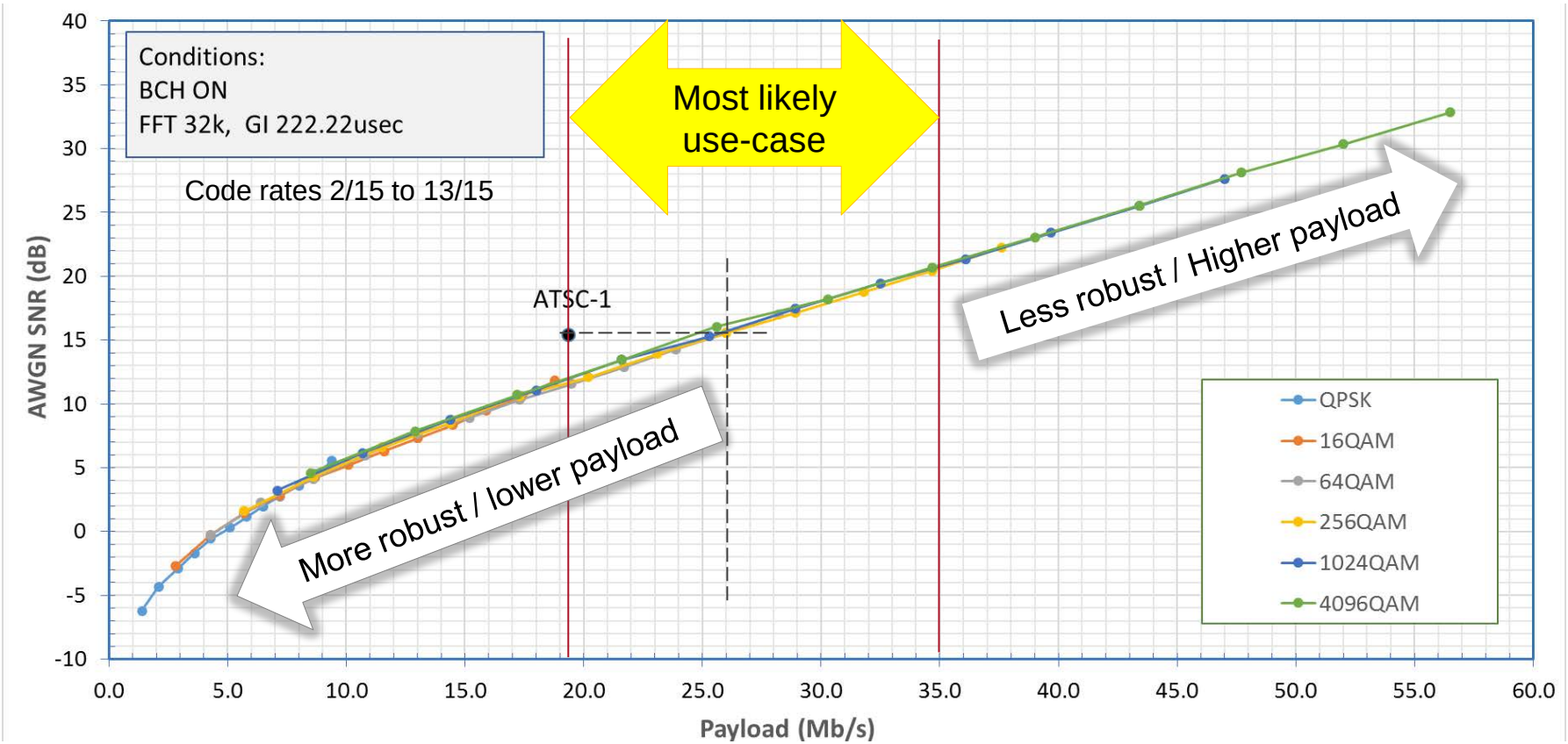
How Much ATSC 3.0 Power Do I Need?



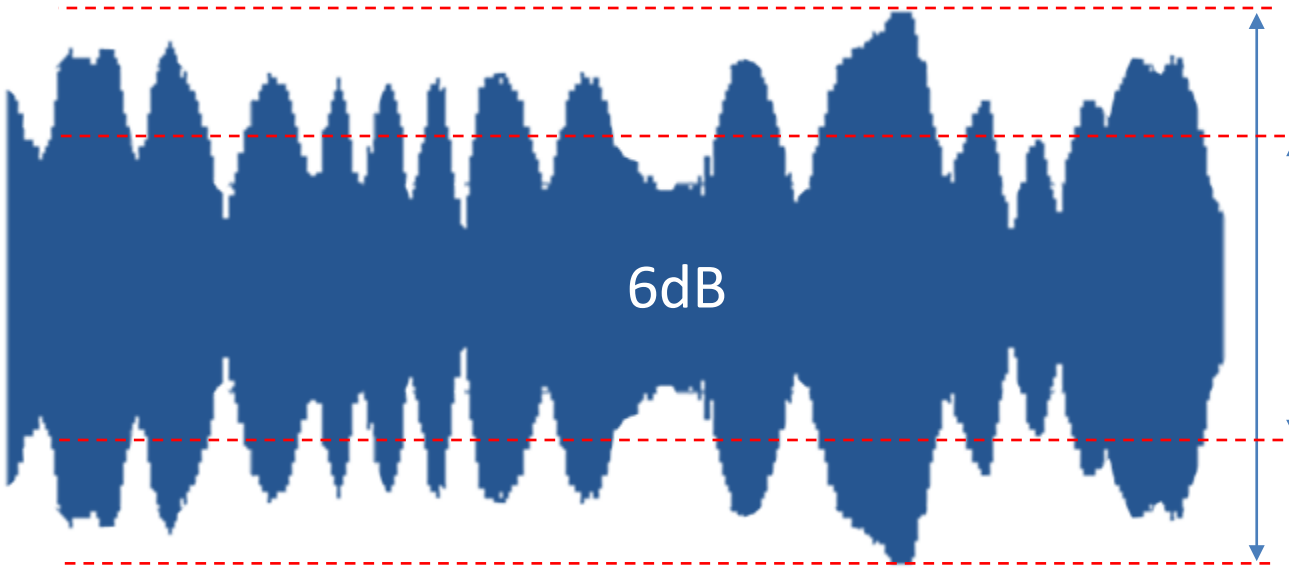
How Much ATSC 3.0 Power Do I Need?

- *Well, it depends….*
- It depends on many factors, such as:
  - Replication of today's service to consumers – or different service areas for different content (e.g. Mobile/SD/HD/UHD)?
  - Is deep indoor robust reception planned, versus just roof-top?
  - Robustness vs. payload (bit rate)
  - Number of services and type of services (PLP's, LDM)?
  - What ERP will be licensed for your 3.0 transmission?
    - *Current thinking is that it may be same as for the current ATSC 1.0*

ATSC 3.0 Payload / Robustness



ATSC 1.0 Peak-to-Average Ratio



Peak Power (W)

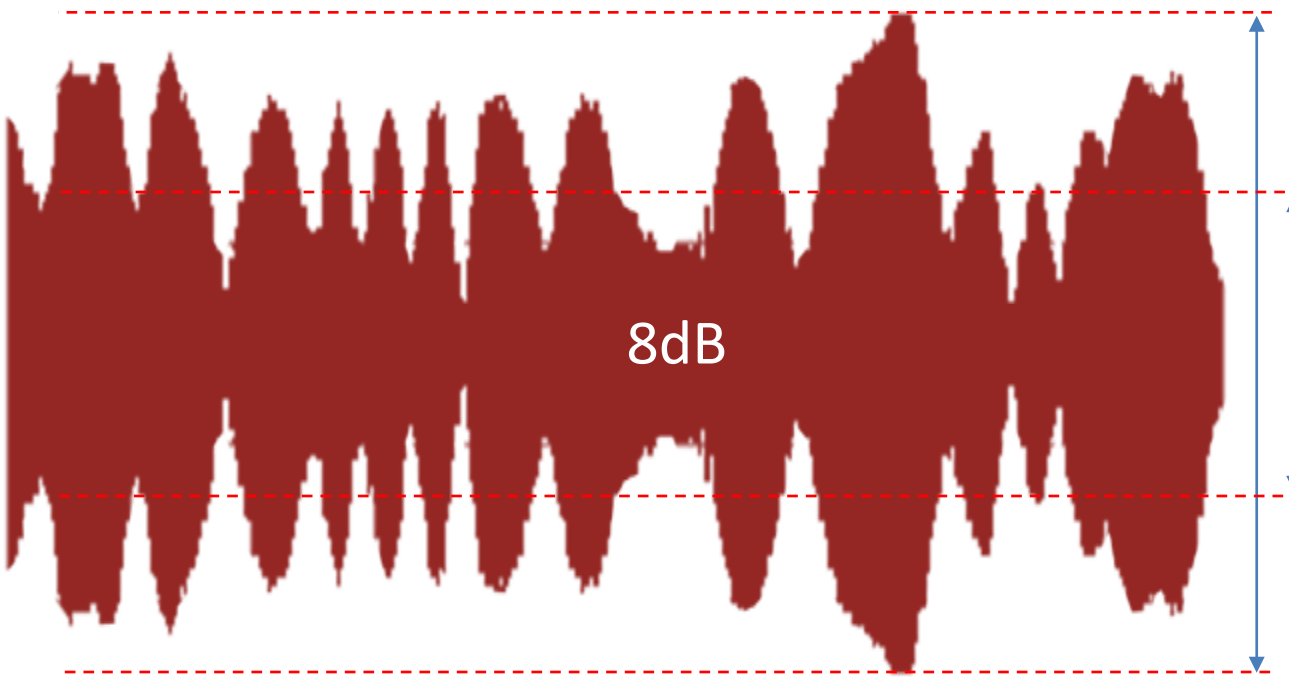
Average Power (W)

PAR

8-VSB = 6dB

OFDM = 8dB

ATSC 3.0 Peak-to-Average Ratio



Peak Power (W)

Average Power (W)

PAR

8-VSB = 6dB

OFDM = 8dB

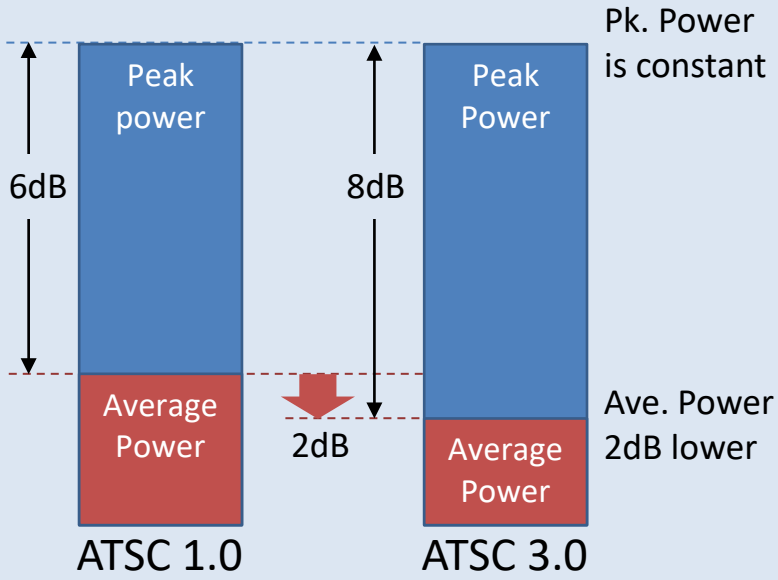
Measured PAR @ Mask Output

Courtesy Joe Seccia, GatesAir

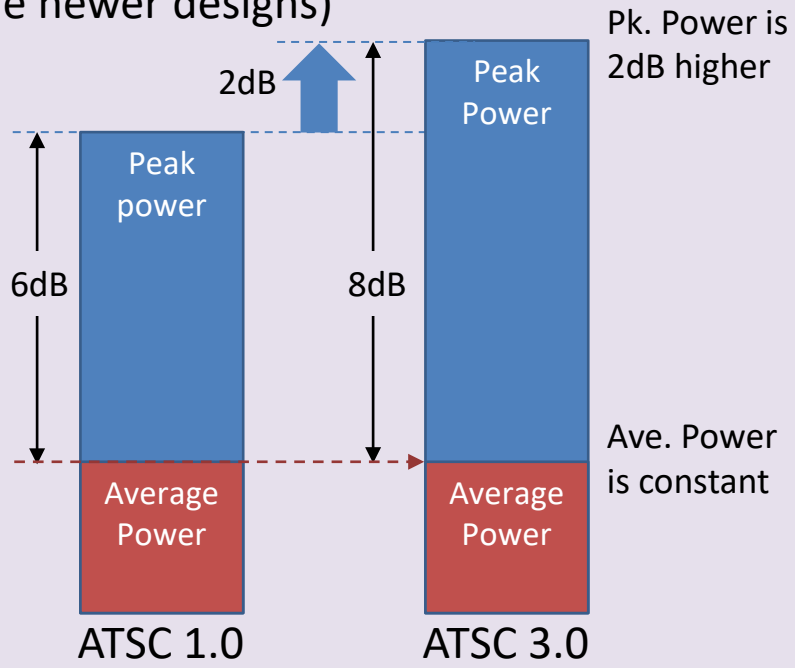
The basis for the ~2dB difference

Transmitter PAR Optimizations

1. Transmitter optimized for 8VSB
(Peak power limited scenario)

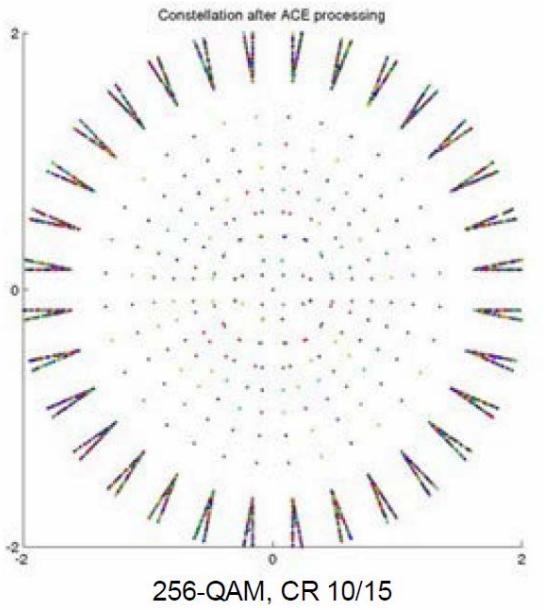


2. Tx optimized for OFDM
(some newer designs)



PAR/PAPR Reduction

- Wait - doesn't ATSC 3.0 have some PAR (PAPR) reduction techniques?
  - Our experience in testing of similar ACE and TR techniques with DVB-T2 shows only about 0.3dB improvement at the transmitter mask filter output



Example of constellation diagram for 256QAM when using the defined ACE algorithm

PAR Reduction in ATSC 3.0

ATSC S32-230r56 Physical Layer Protocol, Annex M 29 June 2016

Annex M: Peak to Average Power Ratio Reduction Algorithms (Informative)

M.1 PAPR REDUCTION ALGORITHMS

The specific algorithms used to reduce peak to average power ratio are left to manufacturers to devise the most appropriate method for implementation on their equipment. For reference, Section M.2 outlines one algorithm for Tone Reservation and Section M.3 outlines a possible algorithm for the Active Constellation Extension (ACE) method.

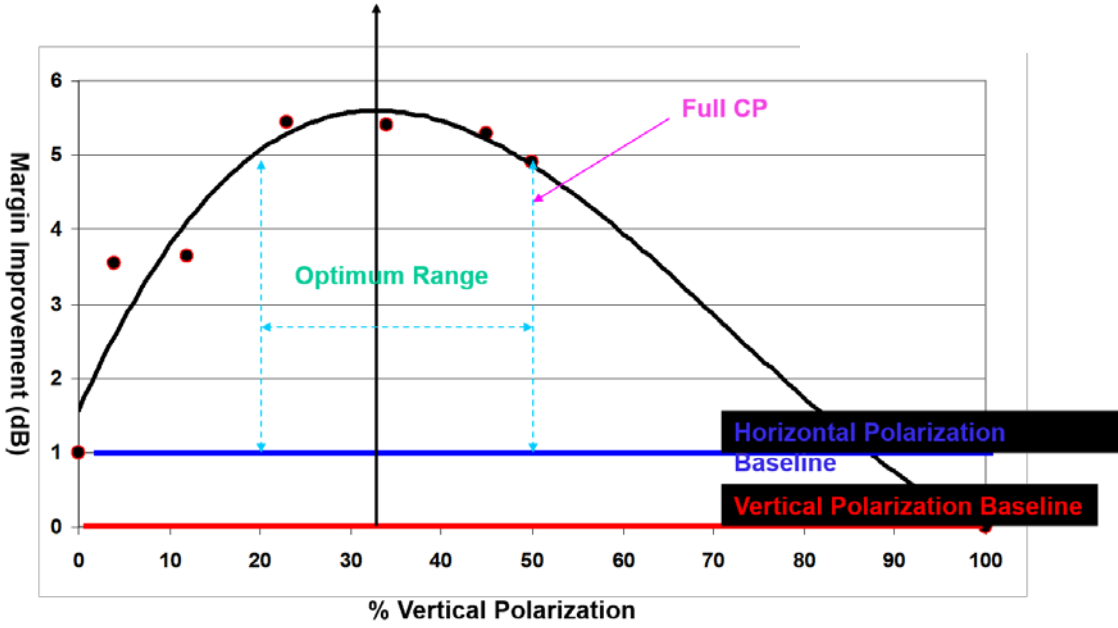
PAR Summary

- A ~2dB increase in PAR at the transmitter output will occur, when switching from ATSC 1.0 to 3.0
  - Keeping the same transmitter average power, results in a peak power increase of ~ 2dB *at the transmitter output*
- Peak energy can increase due to ringing artifacts as it passes through the mask filter, due to the *Gibbs Phenomenon*[1]
- For peak power headroom in RF components past the transmitter an additional "safety" margin should be applied. A practical figure is to use 10dB above average power for peak power ratings.
  - Some RF component manufacturers use even more headroom

1 http://mathworld.wolfram.com/GibbsPhenomenon.html

Vertical Polarization – Is There Any benefit?

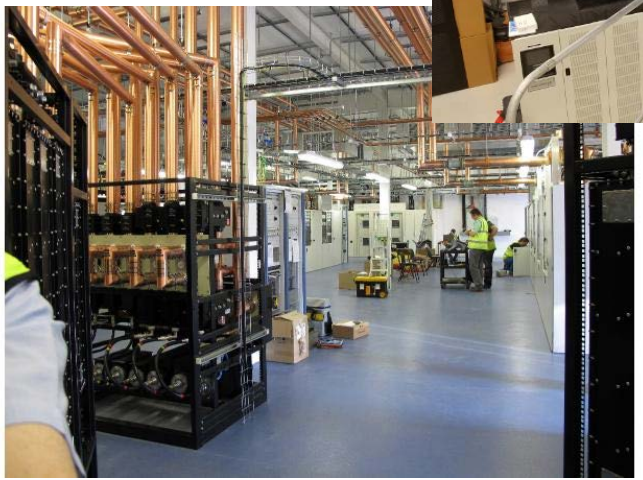
- Some V-Pol signal has been proven to help mobile and deep indoor reception
- 20% V-Pol to 50% V-pol provides optimum benefit
- Note: A 30% V-Pol antenna would increase average tx power by 42.8% (~ 1.5dB) to maintain original ERP



More than 4 dB of margin improvement with 20% < Vpol < 50%

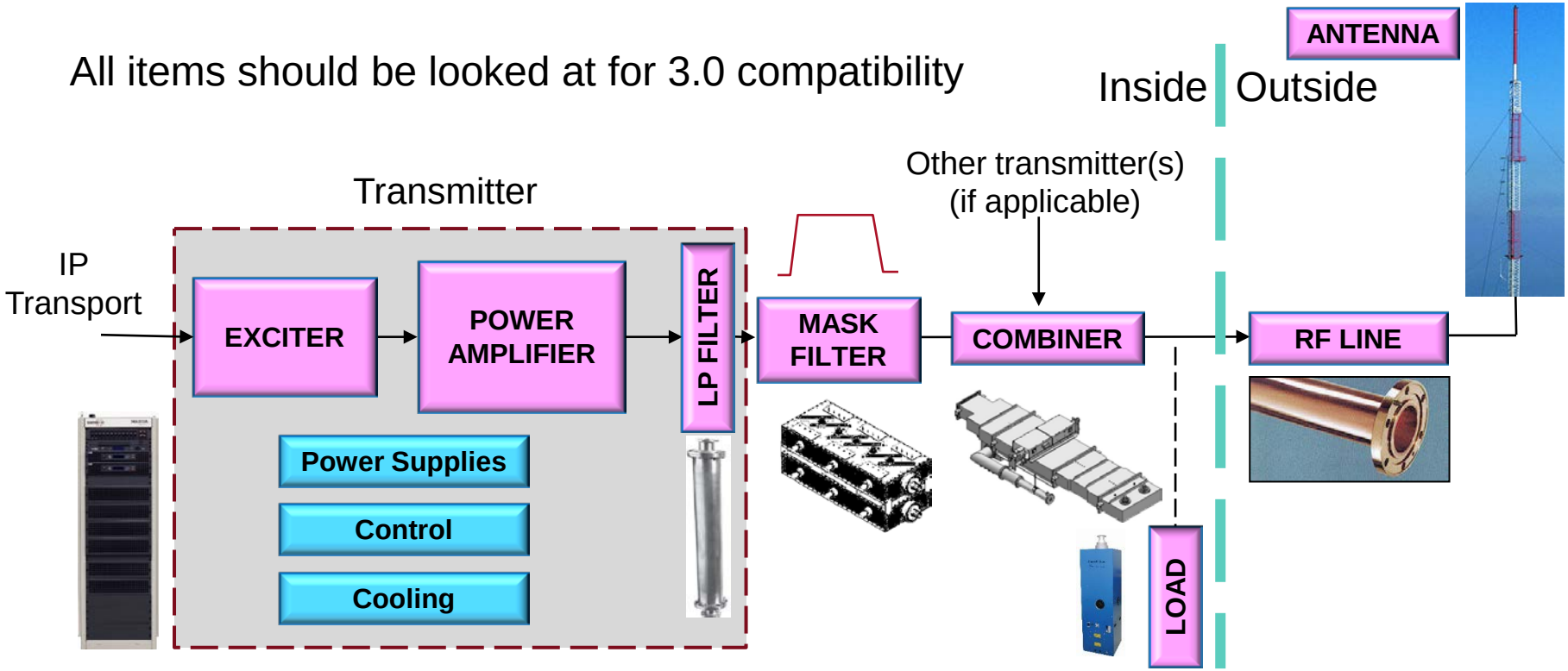
Courtesy: Dielectric

RF Plant Considerations For 3.0



The RF Plant

All items should be looked at for 3.0 compatibility



RF Plant Considerations

- Transmitter ✓
- Mask Filter
- Line
- Test Load
- Antenna

Transmitter

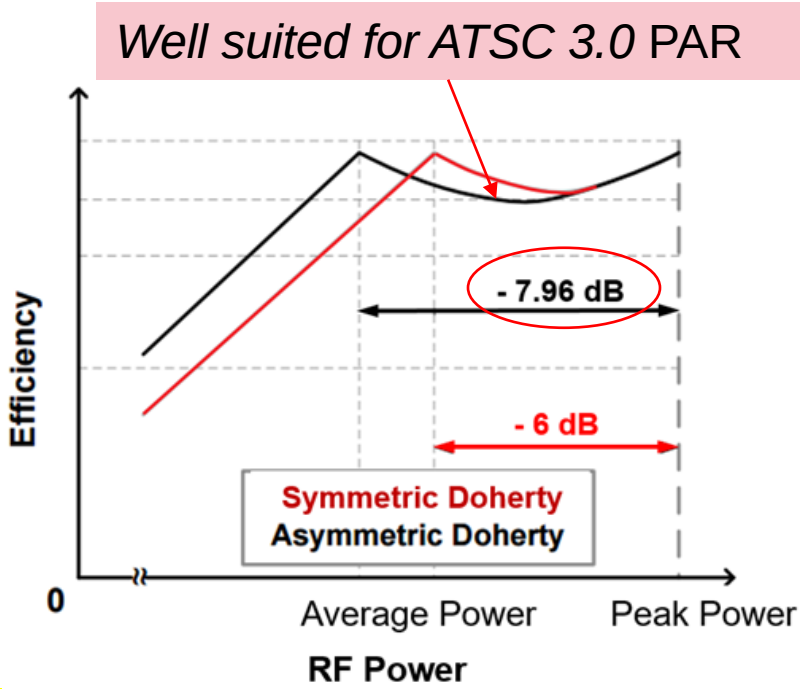
- Does it have an upgrade path to 3.0?
- The good news is – most recent transmitters can be converted to 3.0

Questions you might ask your tx supplier:

- Exciter technology - software update to 3.0 versus exciter replacement?
- Is it big enough - what average power level will I need?
- If I need more power, can it be upgraded later?

Transmitter RF Device Technology

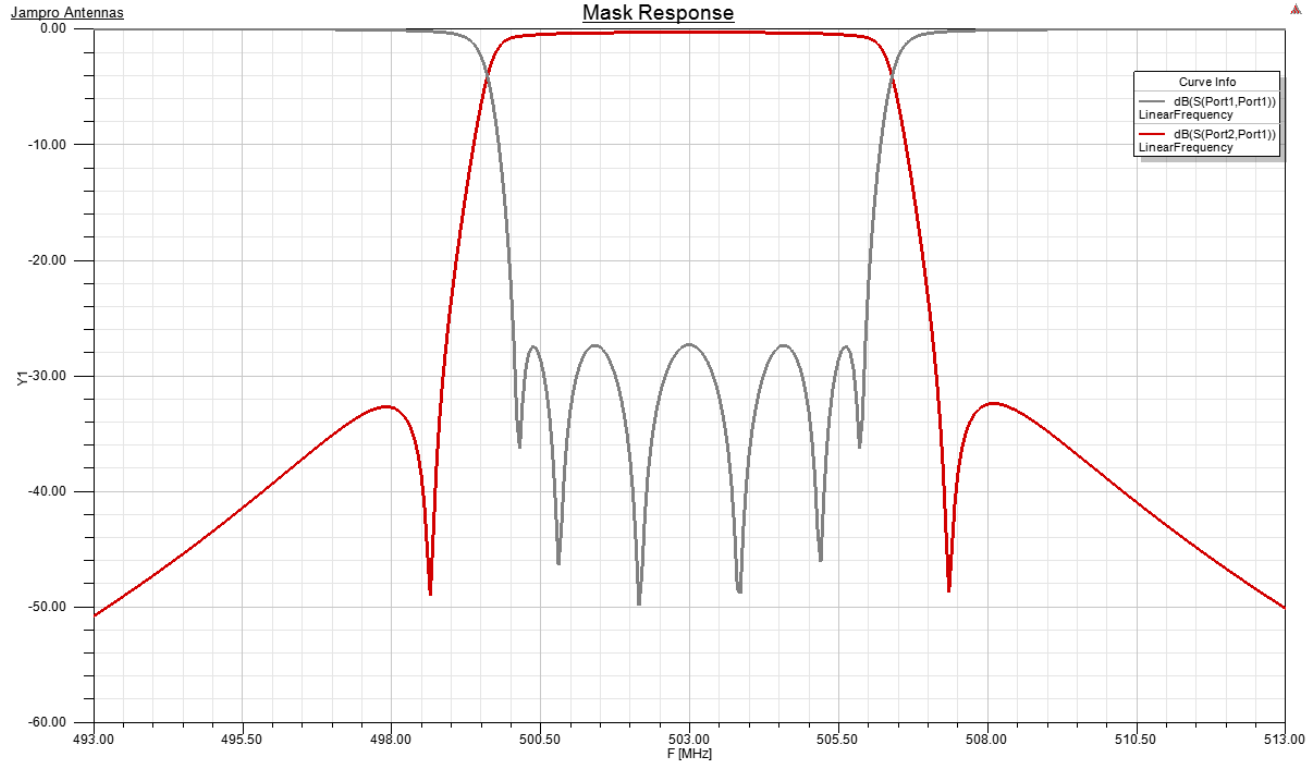
- Asymmetrical Doherty LDMOS Characteristics (Example Ampleon BLF-888E):
- Voltage (Vds, Drain/Source): 50 Volts
- Average Power: 150W (OFDM TV)
- Efficiency (ηd): 52-55% at pallet
- RF Gain: ~17dB
- Doherty back-off (peak/main) 7.96dB
- Excellent ruggedness (VSWR > 40:1)
- Excellent thermal stability
- Three circuit designs can cover all UHF Band
- One RF Amp design can cover the USA repacked spectrum (ch's 14-36)



Symmetric vs. Asymmetric Doherty

RF Plant Considerations

- Transmitter ✓
- Mask Filter ✓
- Line
- Test Load
- Antenna



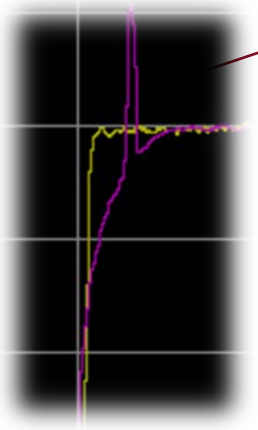
Courtesy: Jampro

Mask Filter - 6 or 8 Pole?

- Ref. FCC NPRM 73-13, 2/24/2017: P22: **1. Interference Protection of ATSC 1.0 (DTV) Signals** *"Petitioners state that the RF emission mask and effective radiated power limits for the ATSC 3.0 signal should remain unchanged and proposed that no changes be made to the OET Bulletin No. 69 planning factors which define service and interference to a DTV signal"*
- Implication is that the standard mask for ATSC 1.0 will be fine for 3.0
- CFR 73.622 defines the mask requirement
- A 6-Pole mask filter will be sufficient, however there is a catch-all statement ***"In the event of interference caused to any service, greater attenuation may be required"***
- **However, many broadcasters and consultants have suggested that 8-pole filters should be used for ATSC 3.0 (The safer bet)**
- **Also, if moving to ch14, get a consultant involved to look at potential interference issues. A more complex and expensive filter may be required**

Mask Filter – Bandwidth (1)

- ATSC 1.0 bandwidth (Nyquist filtered spectrum): **5.38MHz** (@-3dB)
- ATSC 3.0 maximum bandwidth – **5.83MHz** @ -3dB
- Slight filter retuning may be required

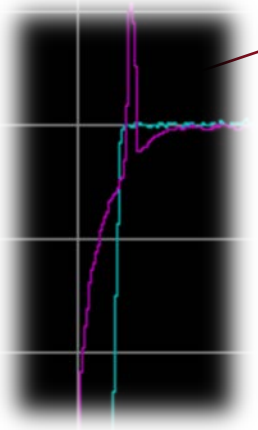


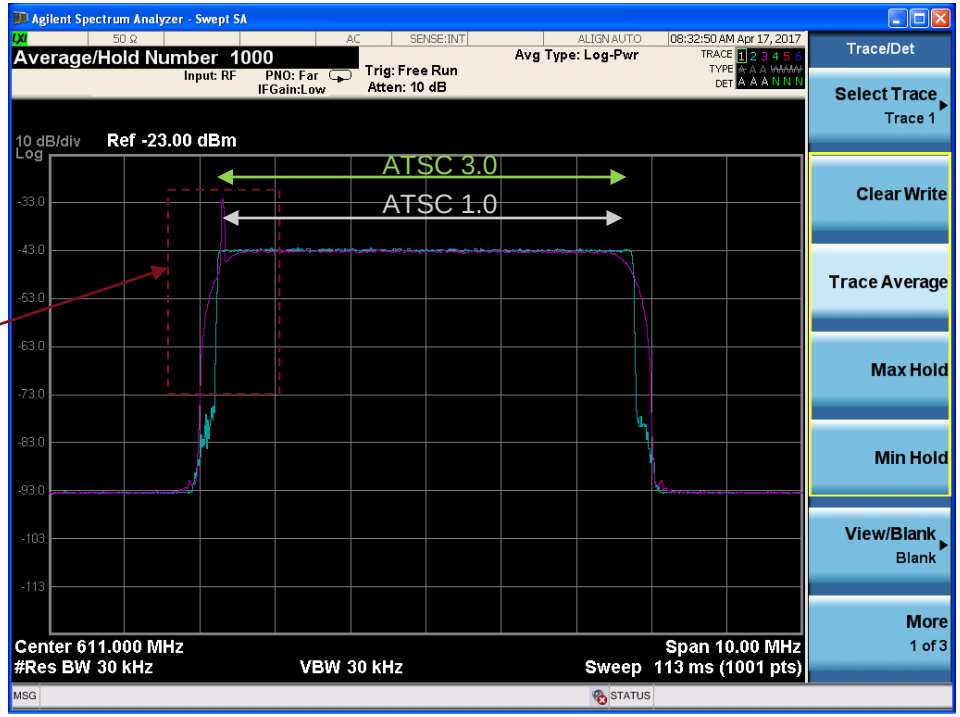
Mask Filter – Bandwidth (2)

- ATSC 3.0 bandwidth can be changed
- Minimum bandwidth is **5.509MHz**
- Minimizes any filter retuning issues

S32-230r56 – Part of table 7.1

C_{red_coeff}	Number of Carriers (NoC)			
	8K FFT	16K FFT	32K FFT	bsr_coefficient = 2
0	6913	13825	27649	5.832844 Max.
1	6817	13633	27265	5.751844
2	6721	13441	26881	5.670844
3	6625	13249	26497	5.589844
4	6529	13057	26113	5.508844 Min.





Mask Filter – Power Handling

- Coaxial Mask Filters may handle the average power but the peak power (and peak voltages) will be greater
- Example 10kW Transmitter, 50 Ohm line:

Modulation Type	ATSC 1.0	ATSC 3.0	ATSC 3.0 with 30% V-Pol
Enter Tx Average Power (kW)	10	10	14.29
Enter Line Impedance (ohms)	50	50	50
Enter PAR 0.1% CCDF (dB)	6	8.2	8.2
Peak Power (kW)	39.8	66.1	94.4
RMS Voltage (Vrms)	1,411	1,818	2,172
Peak Voltage (Vpk)	1,995	2,570	3,072

Note: Adding additional power for V-Pol (43% for a 70/30 H/V ratio)

Mask Filters - Options

- Coaxial Filters are popular and are usually tunable
  - Still a viable option - but check headroom and peak power/voltage
- Waveguide filters have higher average and peak power and much higher peak voltage ratings
  - At least one manufacturer has developed a ”tunable” TE_{101} mode waveguide filter that has been optimized for ATSC 3.0 service
  - Benefits are lower loss (saves $$), higher power handling

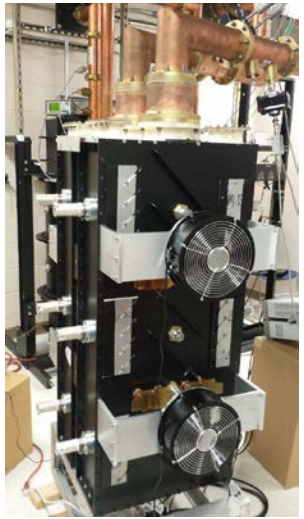
Mask Filters

- A wide array of filters available for all applications:

6-channel mask filter/combiner *(Courtesy – Jampro)*

12.5kW Tunable Coaxial Filter *(Courtesy - Spinner)*

50kW Tunable TE_{101} Mode W/G Filter *(Courtesy - RFS)*



60kW Tunable Air-Cooled W/G Filter *(Courtesy - Dielectric)*

RF Line & Inside RF Components

- Transmitter ✓
- Mask Filter ✓
- Line ✓
- Test Load ✓
- Antenna

Heliax

Elbow

Rigid Line

Test Load

Photo's courtesy - MYAT, ERI, Commscope, Bird Electronics

RF Line & Inside Components

- In general all inside RF plant items should be re-usable for ATSC 3.0
  No major issues expected – but check peak power ratings!
- RF line tuning/matching sections will need to be re-adjusted
- Mask filters may need to be looked at
- Test Load - Check the peak power/voltage ratings for the test load (and include any altitude or VSWR deratings)
- Contact manufacturer if in doubt

Antenna

- Transmitter ✓
- Mask Filter ✓
- Line ✓
- Test Load ✓
- Antenna ✓

Antenna *farm* - Mount Wilson, CA

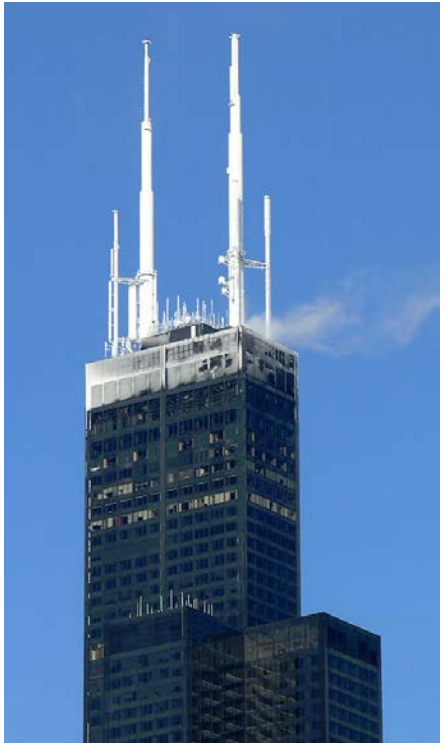
Antenna

- The existing antenna should work for ATSC 3.0 (assumes same channel)

However:

- Check power ratings
- Some V-Pol may help mobile/portable and deep indoor reception
- Remember, adding V-Pol, increases transmitter power

- Talk to your Antenna supplier!



Willis Tower, Chicago, IL

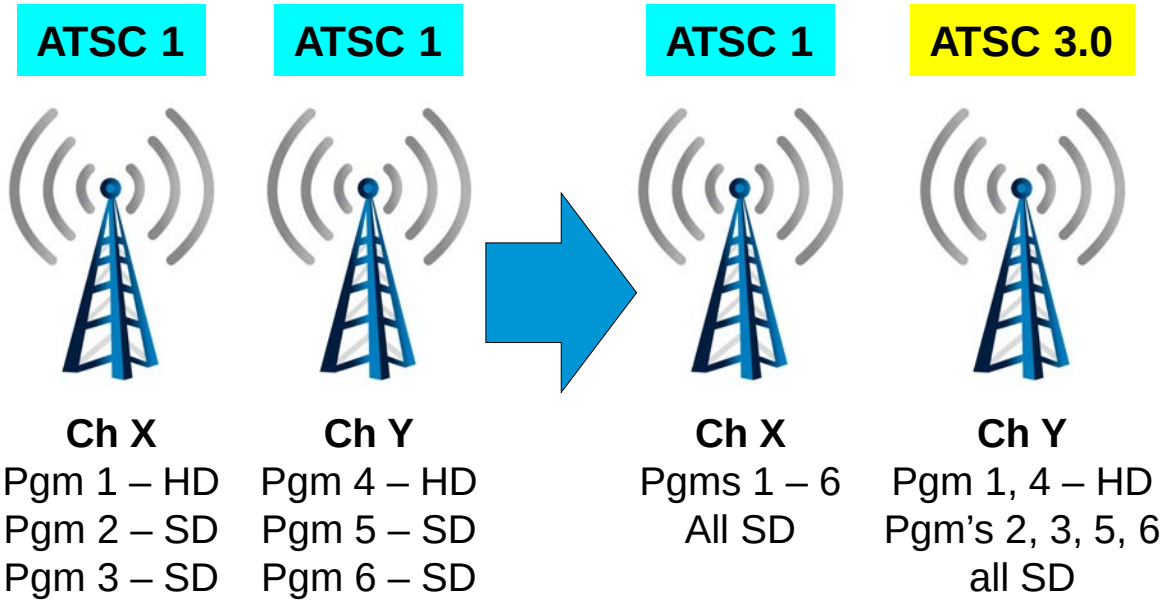
ATSC 3.0 TRANSITION SCENARIOS

Transition Scenarios for ATSC 3.0 Migration

- Assumes re-use current RF channel
- Staying on-air will require careful planning, coordination and some effort
- An incremental change over is likely, as 3.0 TV's and consumer devices become available and viewers change to 3.0
- Two scenarios:
  - Single owner with two stations in same market
  - Multiple owners, single station each in same market

Single Owner, Two Stations

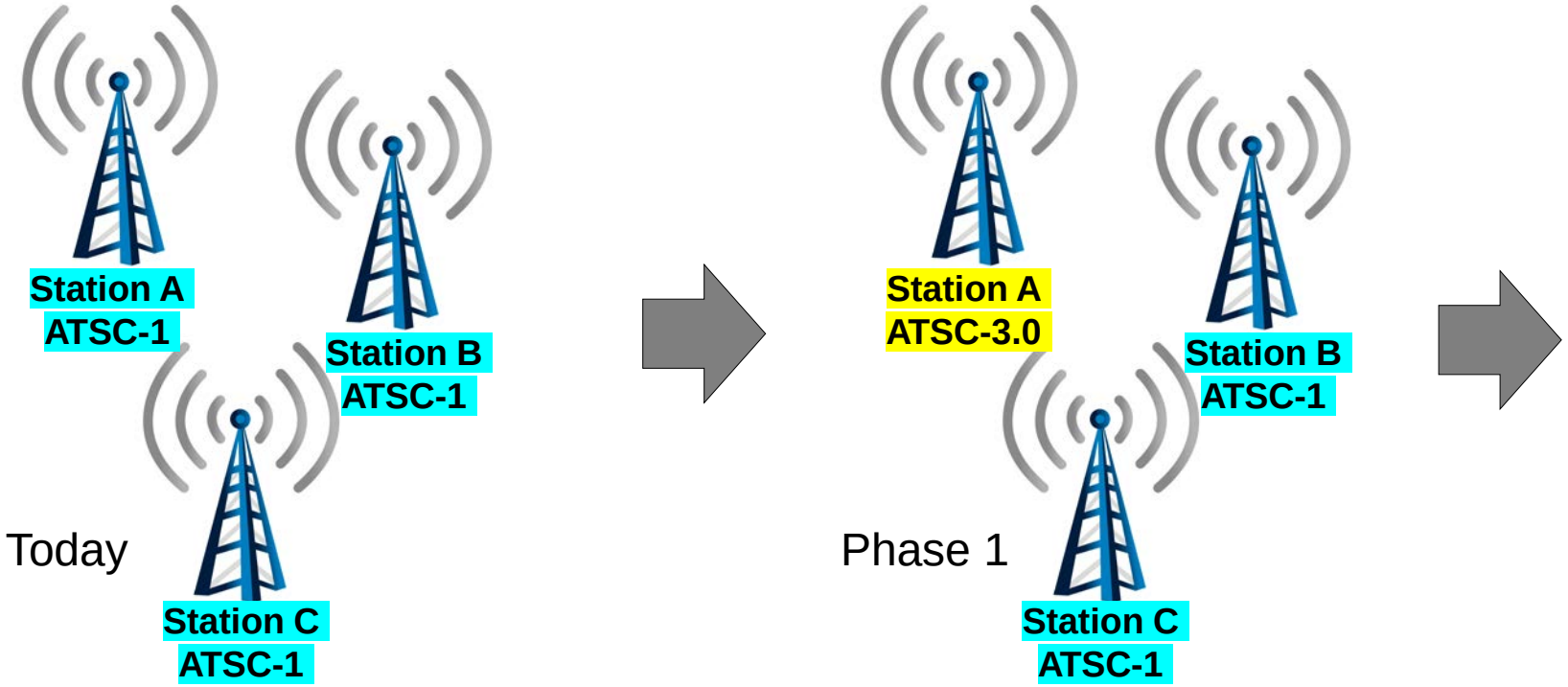
- Convert one transmitter to 3.0
- Put all programs on new tx, inc. HD
- Put all programs on ATSC 1.0 tx in SD
- When analog is turned off convert second tx to 3.0



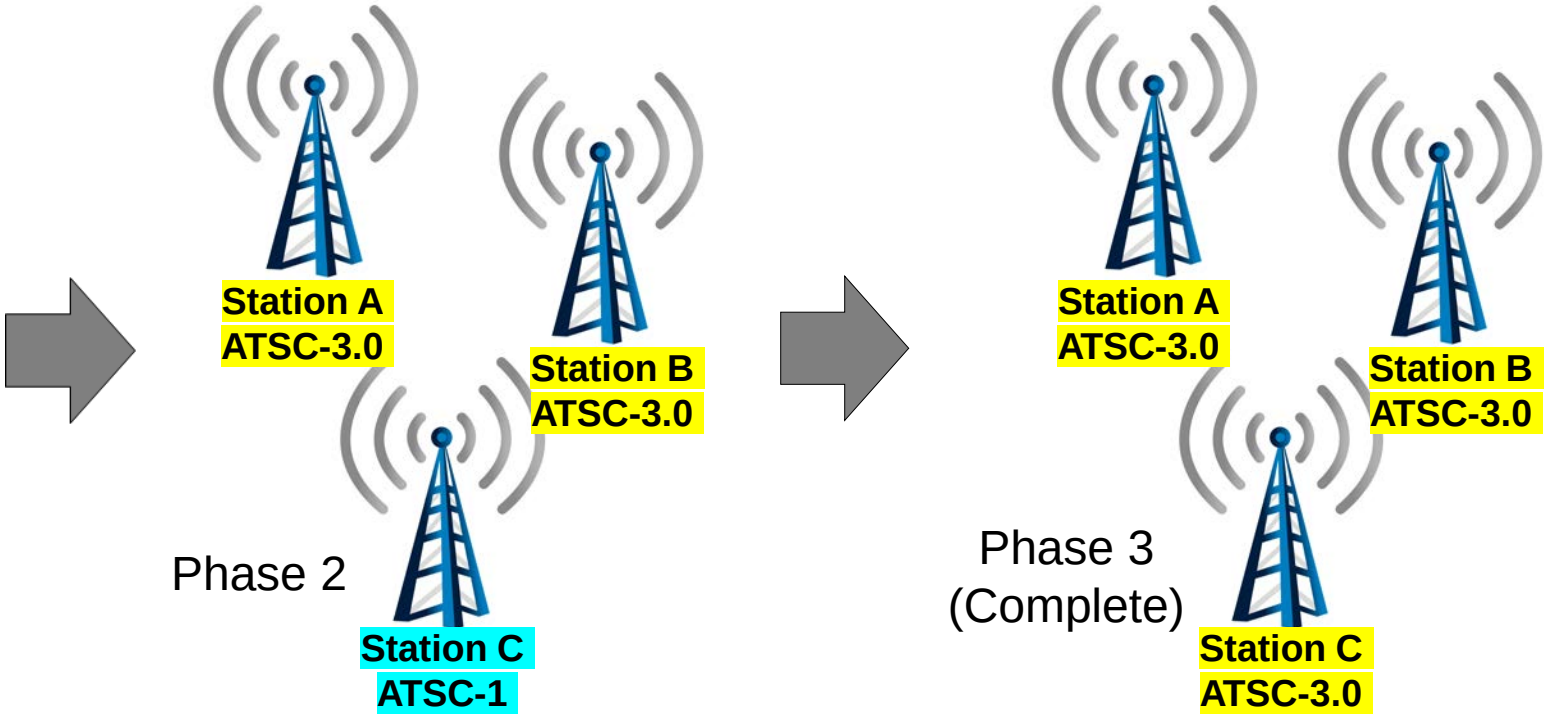
Multiple Owners, Multiple Stations

- Lighthouse Station Concept
  - Proposed by some industry experts - suggests a temporary channel-sharing partnership featuring a “Lighthouse” Station
  - One station, the “lighthouse” converts to ATSC 3.0 first
  - That station seeds the market with programs from all stations in the market
  - the other stations make unused capacity collectively available to replicate the Lighthouse station’s ATSC 1.0 signal, while keeping their own programs
  - After some time, after viewers start watching 3.0 other stations switch to 3.0 until they are all on 3.0
  - When the last station switches over, ATSC 1.0 will no longer exist in that market

3.0 “Lighthouse” Concept



3.0 “Lighthouse” Concept



PLANNING AHEAD

Planning Ahead For 3.0 (1)

- Determine a workable 3.0 transition plan, working closely with the other stations in your market
- Determine the type and number of programs to be carried, the optimum PLP's, types of coverage (indoor, mobile, etc.)
  - Get help from industry experts, consultants as needed
- Go through every item in the RF chain to determine if it can be used, upgraded, or needs to be replaced

Planning Ahead For 3.0 (2)

- Remember to include a 10dB peak power planning factor for all items after the transmitter to allow for peak power requirements
- Determine if you will replace your antenna and if V-Pol is required (remember to adjust tx power and other items as needed)
- If purchasing a new transmitter now, check that it has a simple, cost-effective and guaranteed upgrade path to ATSC 3.0

Thank You!

Martyn Horspool

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