A Post-MPEG-2 Vision

ENCODERS AND BEYOND

Joel Wilhite
Harmonic Inc.

As one sunset ends, a new sunrise begins.

The transition has begun with the addition of new 3.0 transmissions.

ATSC 3.0 Roll out

Alaska

Canada

We are here...

Wisconsin
43 High Power
14 Low power
21 Translators

Where is Vicki
Kipp and Dennis
Baldridge?

Hawaii

Mexico

"ON THE AIR" WITH ATSC 3.0

READYING BROADCASTS

ANNOUNCED TARGET MARKET
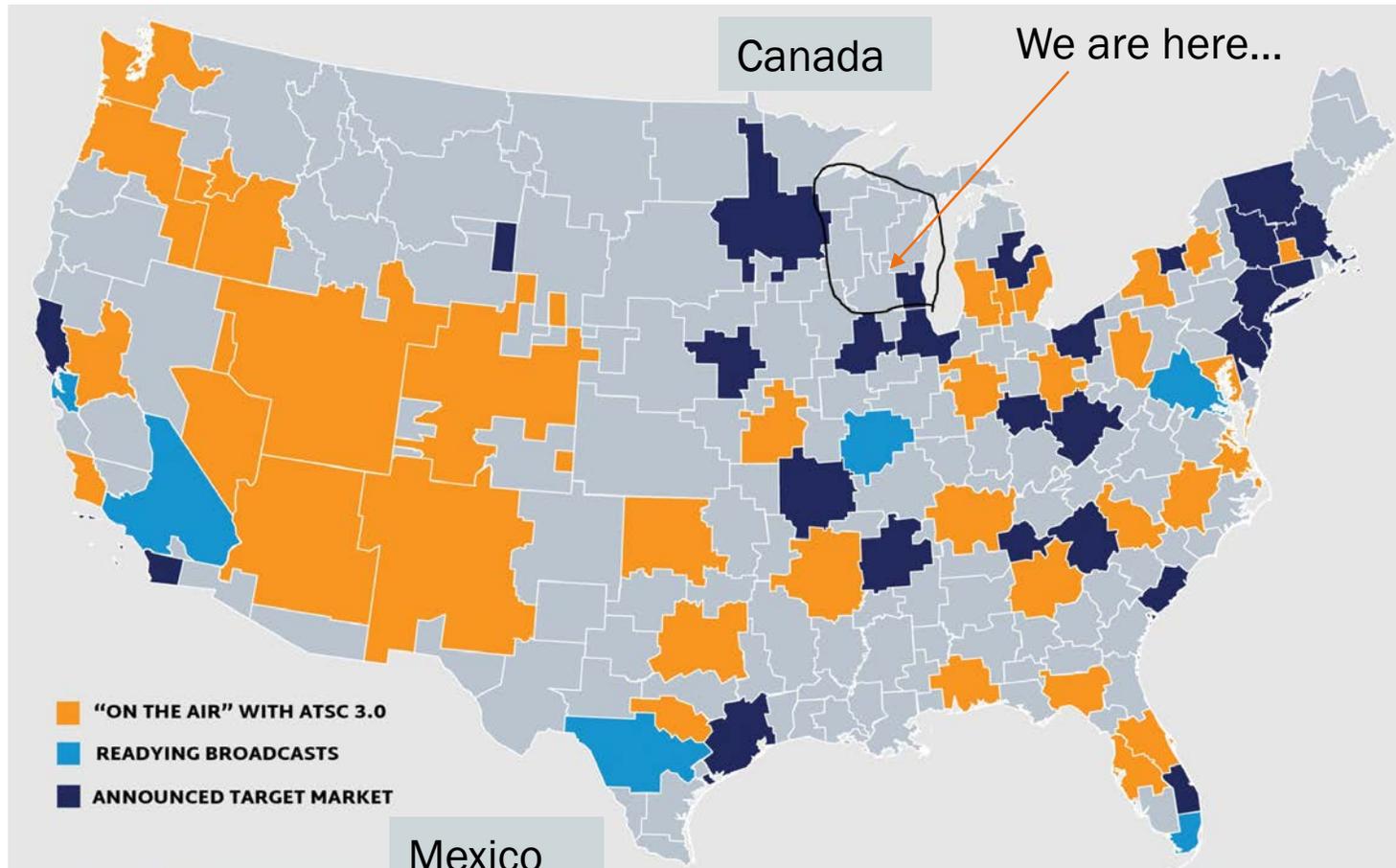
Conversion to ATSC 3.0

SUBMIT PAPERWORK TO CHANGE – Get your budget on schedule

CHANNEL SHARE AGREEMENT – stations MUST maintain 1.0 format for 5 years

APPLY FOR NEW LICENSE – some final FCC paperwork

CONSTRUCTION –
- IP tunnels for moving high speed video traffic between the sites, criss-cross
- Install/upgrade the encoding system, packager, new STL link, new transmitter, etc.
- Start operational tests to validate all the settings and configurations

LAUNCH – Flip the switch,

ADVERTISE – Go buy a new TV

ATSC 3.0 supports cutting edge broadcast delivery

ATSC 3.0 contains 3 core concepts...

1. ATSC 3.0 is new modulation

2. Is all IP based technology

3. Includes an extensible toolbox

A New Modulation
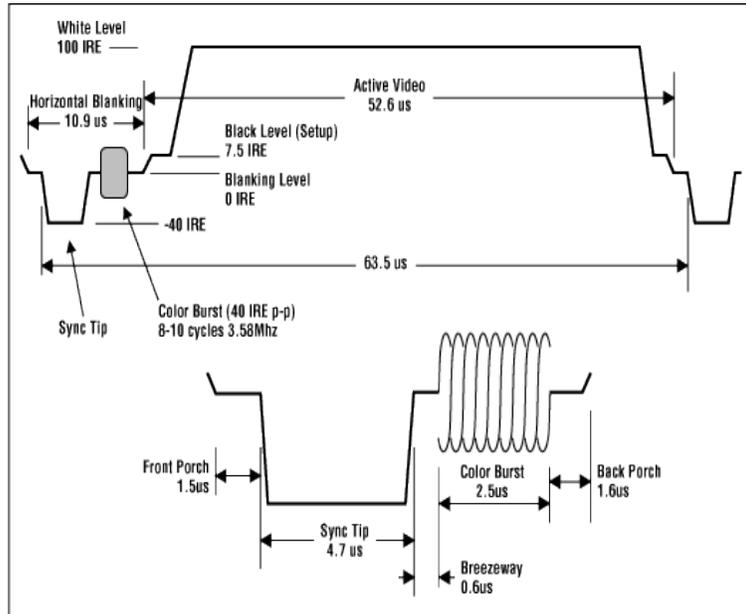
NTSC
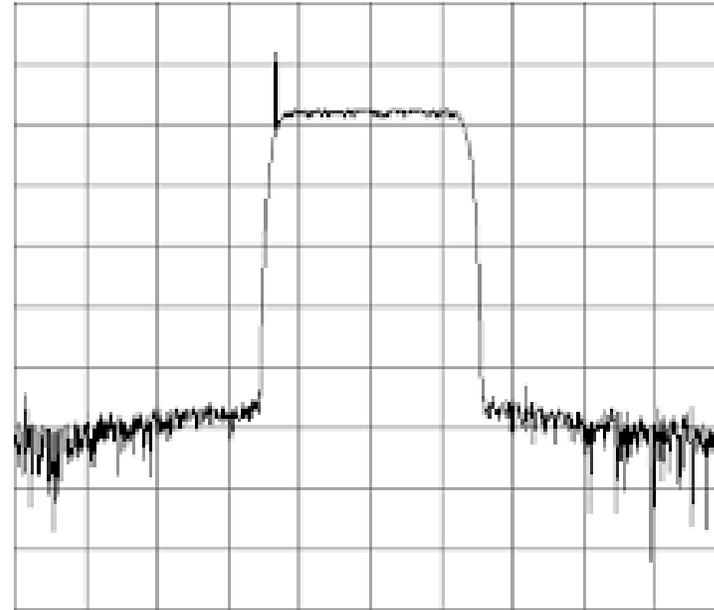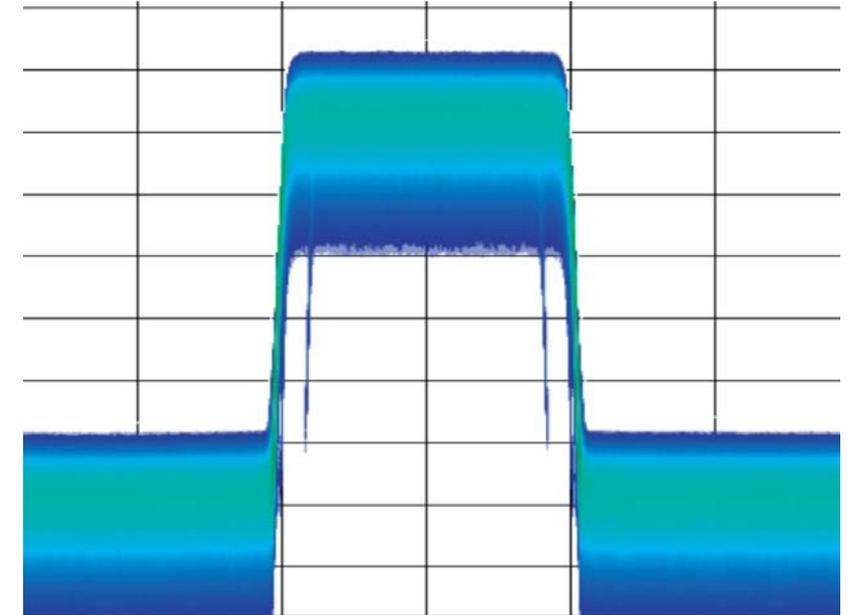
ATSC 1

ATSC 3

ATSC 1.0 Modulation

8VSB history

Back in the early 90s, the standards committee reviewed volumes of research vying for highest performance while minimizing things like Adjacent Channel Interference.

Every amplifier makes side band splatter known as Non-Linear Distortion

8VSB was considered a better solution to solve the ACI problem to help move the industry forward...

- How to introduce a new digital standard and NOT interrupt the analog signals?
  - Adjacent Channel Interference (ACI) between a Desired NTSC carrier and an Undesired ATSC carrier (from non-linear distortion effects) was why everybody had to install very large and expensive RF mask filters
  - Filters are not perfect, and some distortion gets through
  - When 8VSB was compared to COFDM for ACI, the higher incident of adjacent channel interference was caused by COFDM by the smallest of measurement data.
- Engineers specializing in the design of DTV RF mask filters say that with more sections of the filter there would be somewhat less sideband splatter escaping and being radiated, but this is a very costly solution. Few stations would care to bear this expense, which only benefits a competitor or two. – *Charlie Rhodes, 2013*
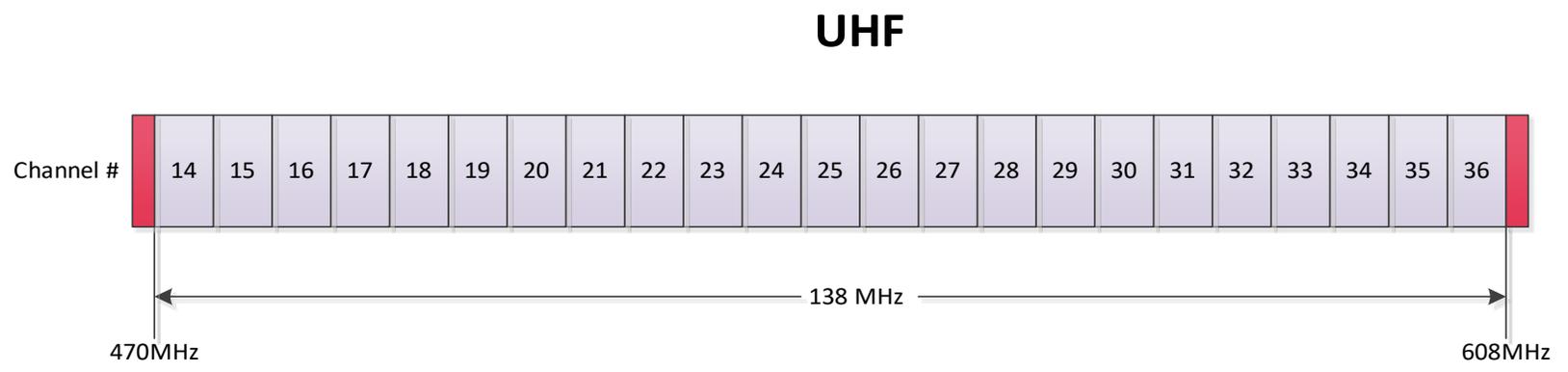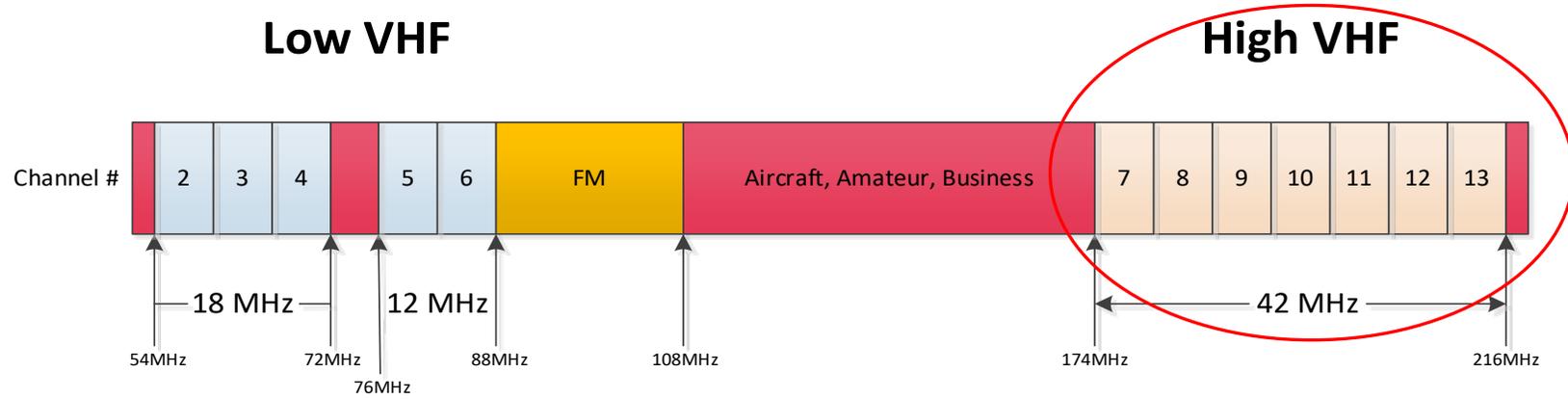
Spectrum is like Real Estate

THEY AREN'T MAKING ANY MORE OF IT.

ATSC 3.0 Modulation

A3P future

ATSC 3.0 modulation is based on non backwards compatibility to ATSC 1.0.

Then the repack forced the issue of adjacent channel interference to the fore front but this time, 8VSB next to A3P (ATSC 3.0 Physical layer)

… extremely tight packing of ATSC signals may prove to be practical. If so, we can realize 100 percent spectrum efficiency as ATSC signals can occupy contiguous channels if all transmitters are co-sited. For example, with analog TV signals, the high VHF band of seven channels could support no more than four analog TV signals on odd Chs. 7, 9, 11, and 13; only three if the channel numbers are even, 8, 10 and 12. _We could load all seven high VHF channels with ATSC signals if their transmitters are co-sited._ If this works for the present ATSC signal, it should also work with whatever the ATSC proposes as the next generation of DTV for North America. – **_Charlie Rhodes, 2013_**

Today, we have a more flexible, adaptable system which is far better system compared with 8 VSB. It very closely follows the Shannon Curve.

Bit Interleaving, Coding, and Modulation Performance
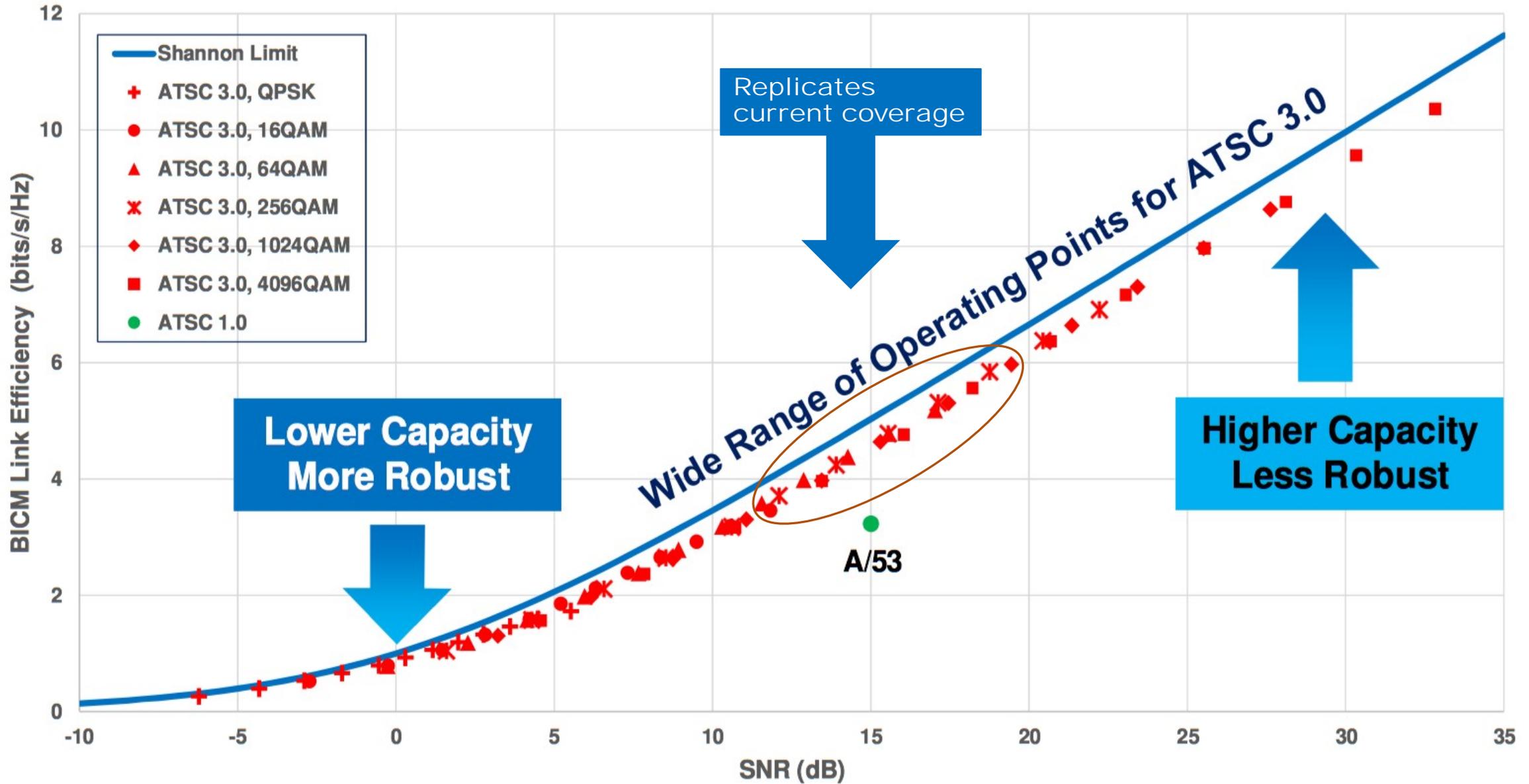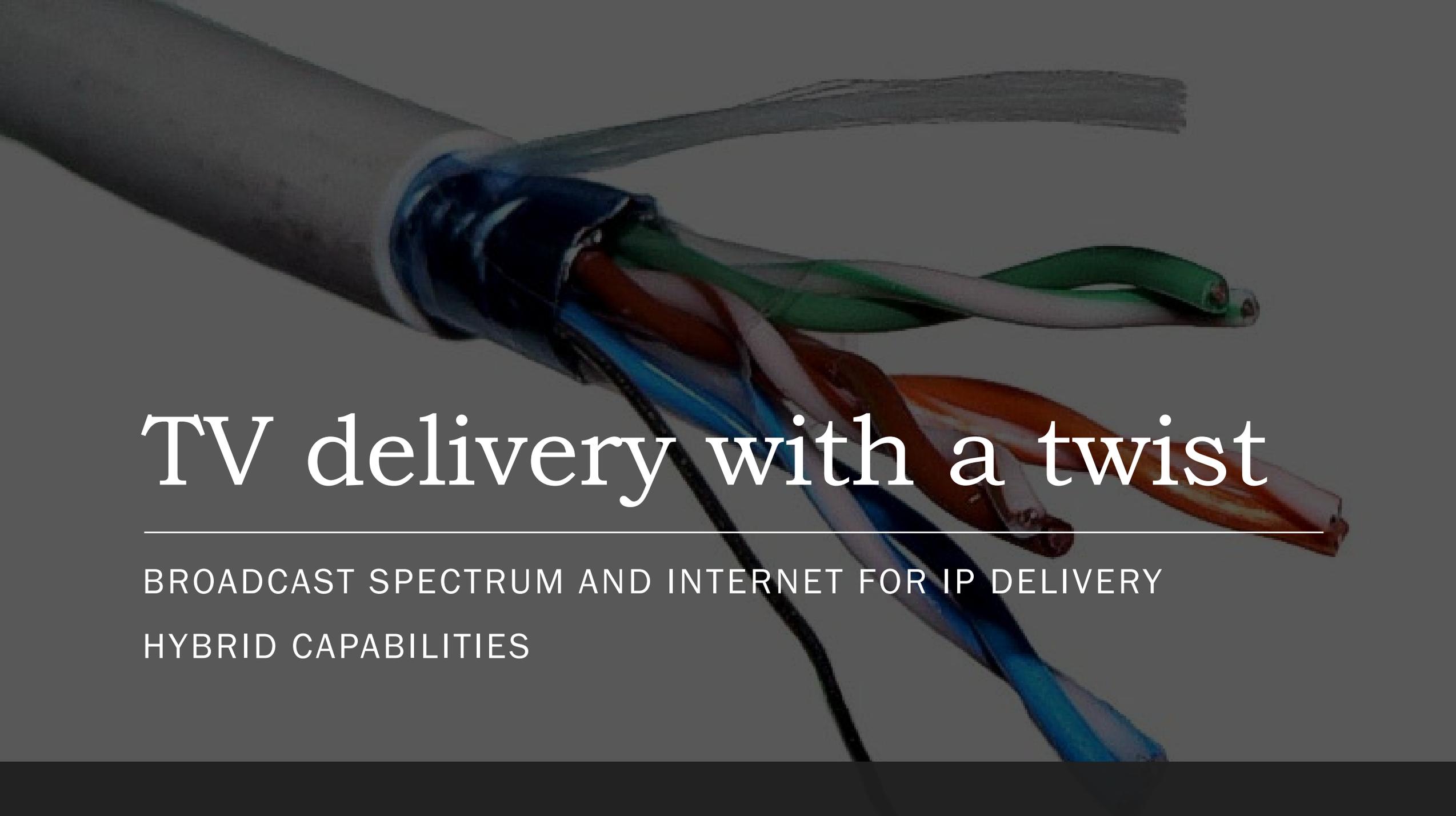
TV delivery with a twist

BROADCAST SPECTRUM AND INTERNET FOR IP DELIVERY

HYBRID CAPABILITIES

ATSC 3.0 means...
All IP Infrastructure

All of your IT skills will be tested, this is not a drill.

"The question is do you hire a TV guy and teach them IP or do you hire an IT guy and teach them TV?" – *Richard Friedel, EVP FOX*

The introduction of a MULTIPLEXER in the ATSC 1.0 standard created the use case for MULTICASTING. Multiplexers today include IP and ASI interfaces. Most now also include SRT support.

The introduction of a PACKAGER in the ATSC 3.0 standard creates the use case for PUBLISHING. The number and type of packaging delivery options doesn't stop at DASH.
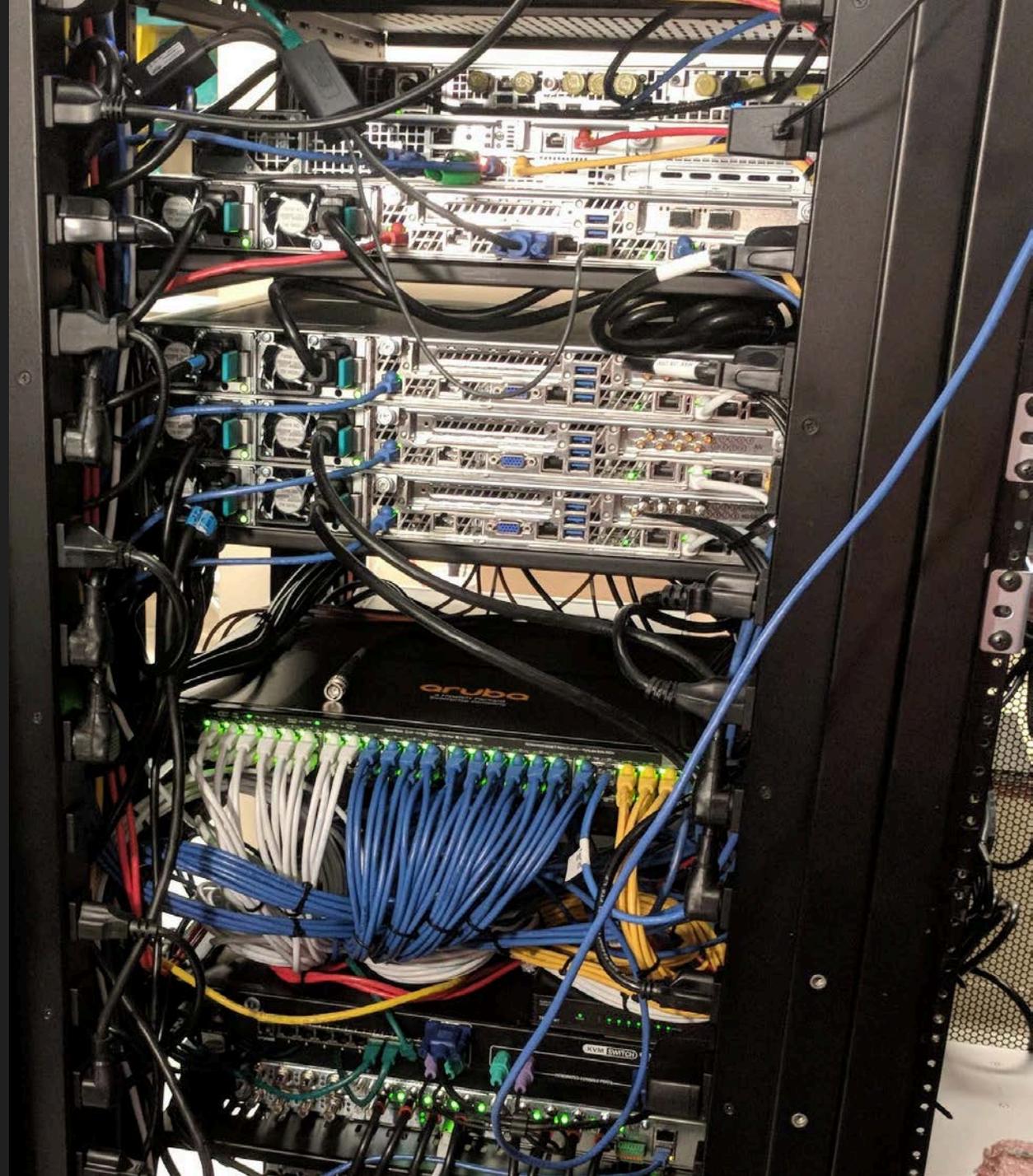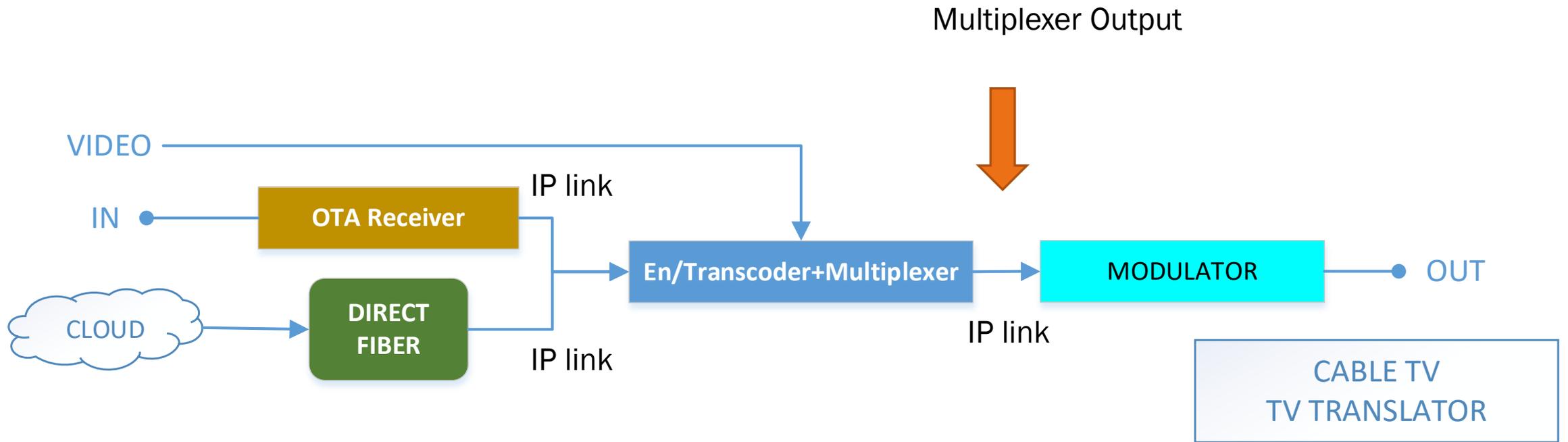
A typical US ATSC 1.0 TV / LPTV / Translator

...or a Cable TV delivery system... A process for converting Layer 0 to Layer 1 and back again, RF in, RF out. Adding IP interfaces, introduces "POINT CASTING". TV delivery from one or more cloud computers is used to feed all transmitters, at all sites. A head end point to distribute TV/IP to any location connected with IP connectivity.
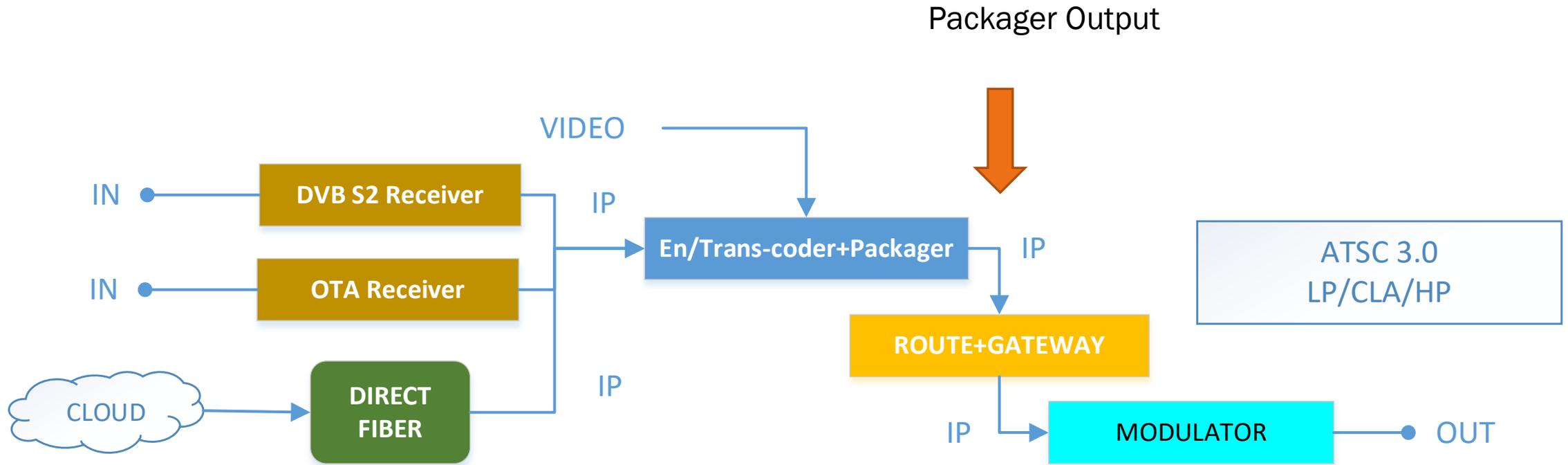
A typical US ATSC 3.0 Station (lighthouse)

(may include Cable TV delivery) A system for delivering ATSC 3.0 service requires 5 distinct processes which can be delivered in 3 or 4 devices. TV delivery from one or more cloud computers is used to feed all transmitters, at all sites. A head end point to distribute TV/IP to any location connected with IP connectivity. SRT pipe city.

3.0 Translators

❑ If you are the first station in the market considering to start 3.0... GREAT!

❑ The next step is to remap the delivery path of the channels carried at all your sites

  ❑ Translators will not need 3.0 processing equipment to convert the content on day one...

    ❑ Assumes all of the channels are carried in the market on another frequency for five years

  ❑ Once 50% of the TV transmitters in a market are operating in 3.0 mode, this is the tipping point where every station in the market is duplicating their signal <mark>twice if not three times</mark>.

    ❑ ATSC 1.0

    ❑ ATSC 3.0

    ❑ MVPD and of translators

  ❑ Broadcasters are transmitting some number (X) of channels "today" then when channel share starts add more channels of encoding up to doubling the encoder capacity (X + Y).

  ❑ Translators will need to manage 2 or more encoder profiles for every stream being broadcast 5 years from now. This points to heavy transcoding requirements when not using a bent pipe RF solution (PLP out is PLP in).
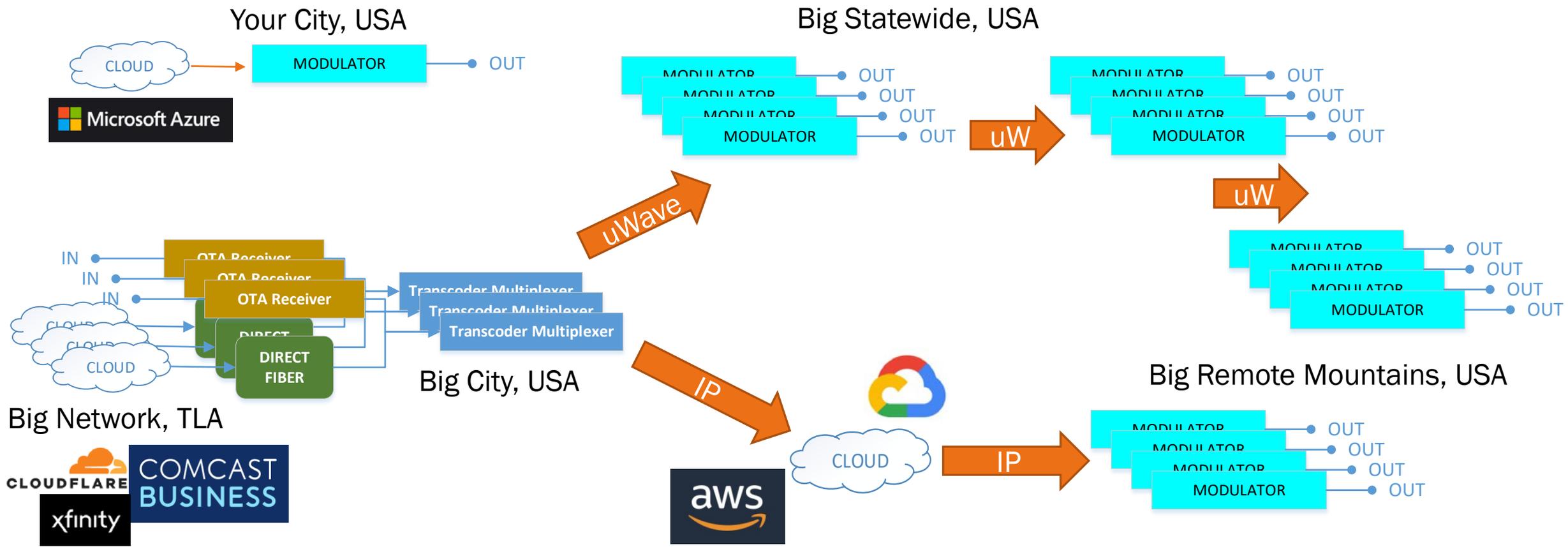
IPTV – all IP delivery model using SRT

Microwave link or commercial "hilltop" IP distribution models, and if fiber shows up, great!

Maximize Your Multiplex

THE GREAT RAT RACE HAS BEGUN

WHITE PAPER AVAILABLE ON REQUEST...

Channel Sharing = Larger Pools

❑ **ATSC 1.0 Stations have started broadcasting in AVC Video** (Mixed codec statmux pools)

    ❑ We revealed this day would come back at NAB 2017 Conference, it only took 2 years

    ❑ There are limits to processing and the resources in ATSC 1.0 (MPEG 2) and still look good aren't there.

❑ The number of TV Stations adding more channels has dramatically increased in the last year…

    ❑ DOT TWO channels generate revenue to help boost revenue in a precarious market

    ❑ The greater number of DOT TWO channels is pushing harder on the on-air statmux pool

    ❑ To make the ATSC 3.0 lighthouse solution possible, the 1.0 stations are required to maintain the primary channels for the next 5 years

    ❑ Sharing is caring… I have no idea how the financials work in a broadcast share between two or more stations, seek other guidance

Q: What's after MPEG-2?

H.264

H.264

- H.264: ITU/AVC/JVT proposed specification for video compression technology aka H.264, MPEG-4 part 10, AVC

Differences between H.264 and MPEG-2

- H.264 vs MPEG-2:
  - multiple motion estimation blocksizes, e.g. 4x4, 4x8, etc...
  - multiple reference frames for motion estimation prediction
  - deblocking filter in the motion compensation loop
  - high-performance transform coefficient prediction
  - adaptive transform coding block size
  - context-adaptive arithmetic entropy coder
- H.264 requires more processing power than MPEG-2
- H.264 delivers double the performance of MPEG-2

Overlapped Block Motion Compensation
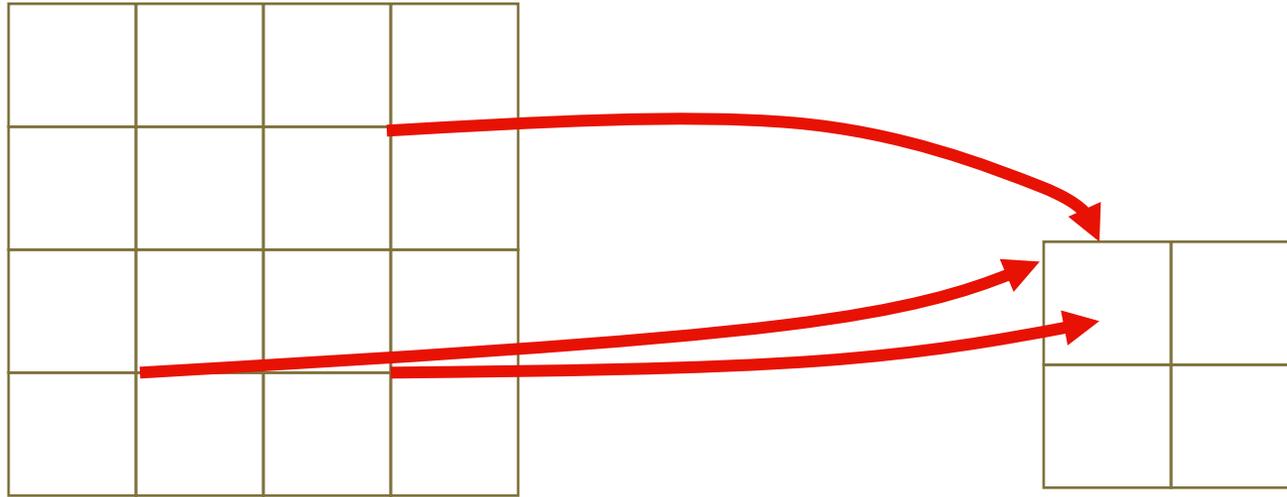

Each quadrant of MC block uses its nearest neighbors, weighted at each pixel position

It chops...

MC Loop Artifact Removal Filtering
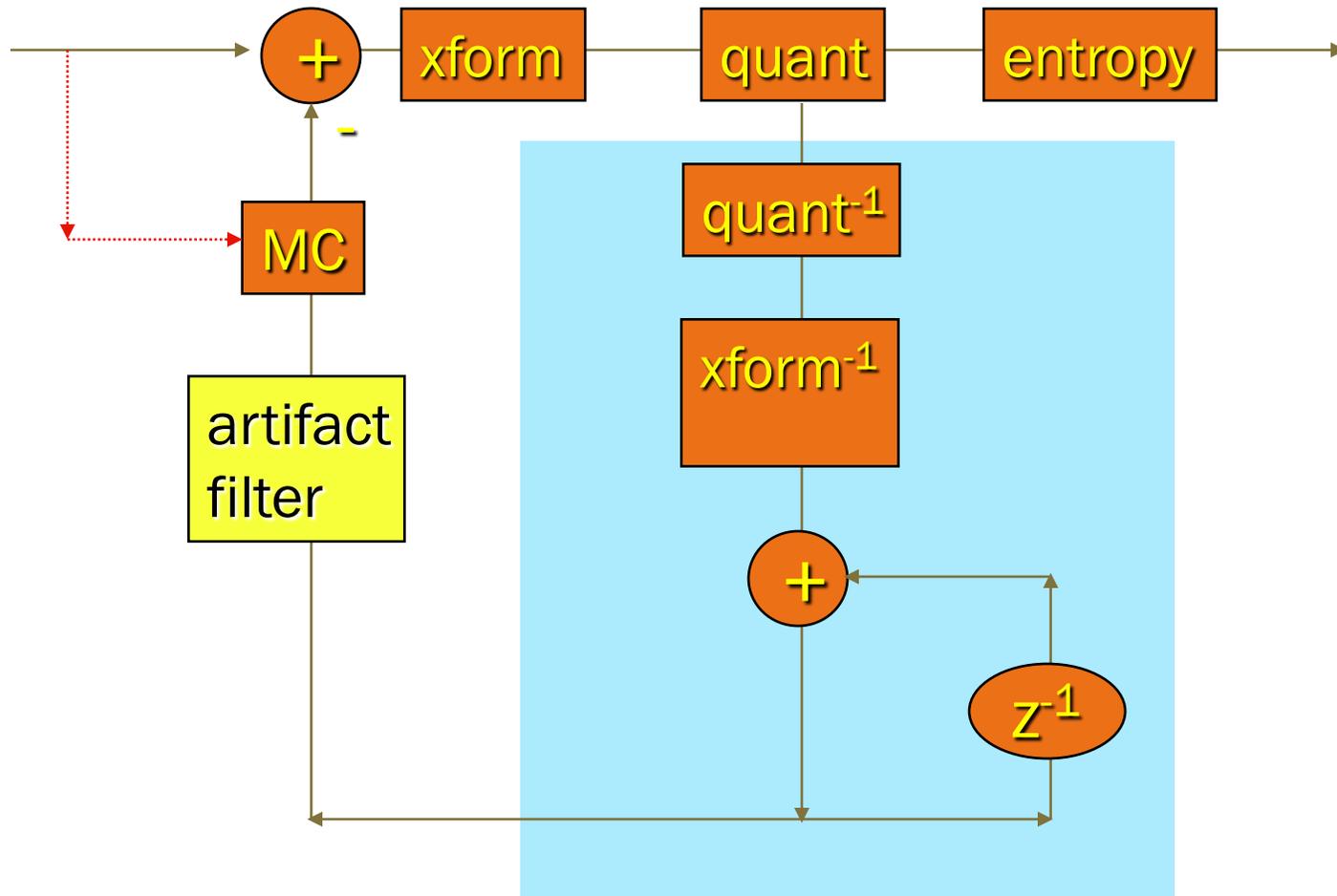
It slices...

Quarter Pixel Motion Estimation
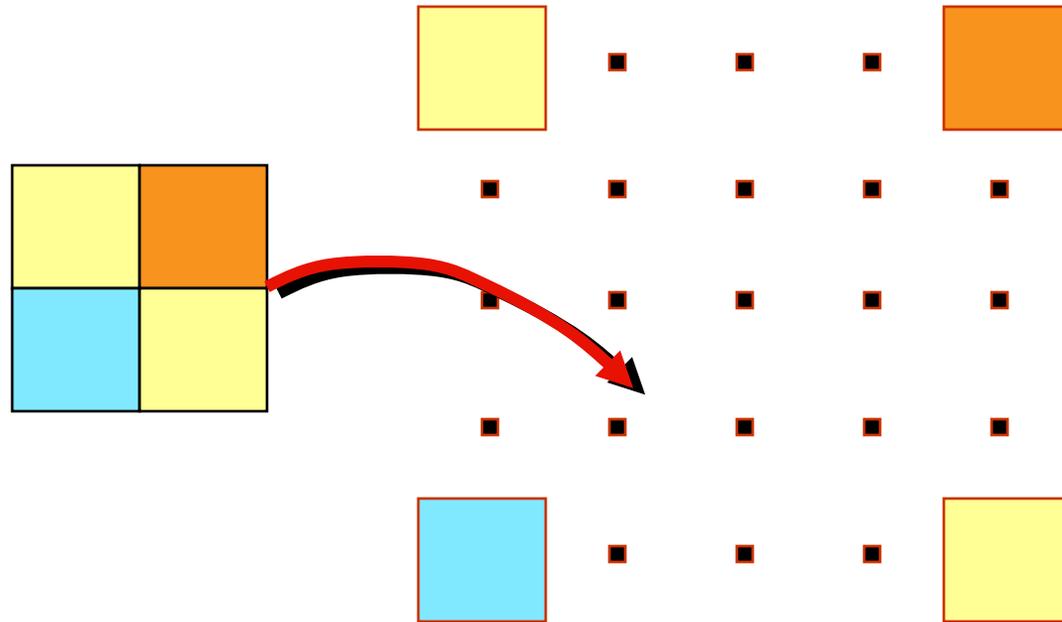
Uses high-quality interpolation

It dices...

Improved Prediction
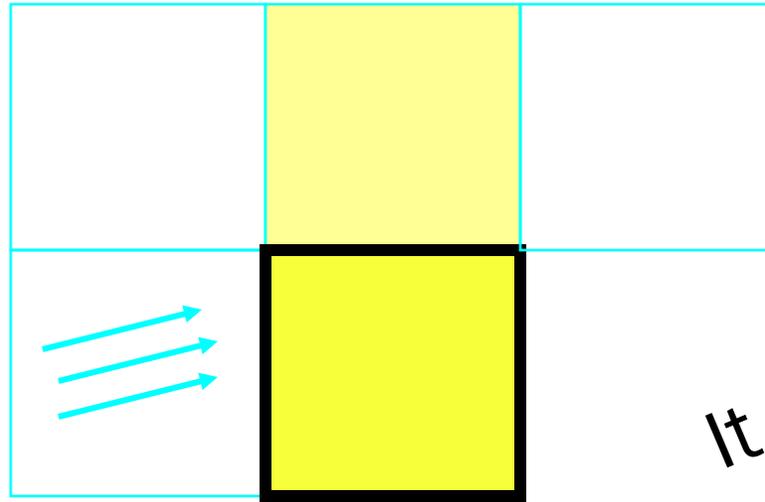
It makes julienne fries...

Motion, brightness of neighbor blocks steers prediction for
motion vectors, transform coefficients

MPEG 2 vs. AVC

Quarter-pel motion compensation
- better subpixel interpolation -> ==sharper pictures==

Multiple motion compensation block sizes

Multiple Intra prediction modes

More reference pictures

Flexible GOP structure
- B pictures can be used as references

CABAC - a form of entropy encoding

In-loop Deblocking filter

Single slice per picture
- ==greater efficiency== with many coding tools

Next Steps for ATSC 1.0

While A/72 satisfies the documentation requirement on how to transmit AVC in ATSC 1.0

And while the FCC says ... "as long as the main channel is carried in MPEG 2"

And while most if not all the new smart TVs do support the AVC codec

We are left with a commercial / industry problem... as NOT all TVs will work on day one.

The industry doesn't have a good answer when the phone rings, and it will ring. It always does.

We ask the make and model and when they bought it they ultimately say "time to buy a new TV"

When the new services started and the calls came in, our data shows us the number of complaints about other problems unrelated to A/72 far out strip the numbers related to A/72

Streaming to Phones

YOUR OTHER TV

CBRS solutions

A Key Business Enabler

CBRS 3.5GHz has 3 tiers, Incumbent Access, Priority Access, and General Authorized Access.

How Private LTE Works

"Any organization can control its own Private Cellular Network.
By deploying localized micro towers and small cells, similar to access points,
the operator can act like a scaled-down version of a public cellular network.
The exception here the licensed organization controls OPSecurity and Quality
of Service (QoS) but with no recurring payments to carriers. Private
LTE networks leverage either licensed spectrum; unlicensed spectrum; or
shared spectrum, such as Citizens Broadband Radio Service, or CBRS."

Cradlepoint.com

New TVs, New Technology

A QUICK REVIEW OF THE NEW TECHNOLOGY COMING SOON TO A TV NEAR YOU...

Acronym Soup

DRM – Digital Rights Management, scrambles your content. Stops another AEREO, Locast from starting up.

HDR – High Dynamic Range – Pick one, not three, and then comes the rub…. Which one?

WCG – Wide Color Gamut – we are increasing the color volume to allow 10 bit luma and color to better represent the pixels.

DAI – Dynamic Ad Insert, ATSC 3.0 is CLIENT-SIDE ad insert, hope you have a good application

HFR – High Frame Rate – video over 60fps, 3G-SDI supports up to 1080p60Hz, so 2 wires (6G) is needed

DFR – Dynamic Frame Rate – a new technique being developed by Harmonic to support UHD with HDR at breathtaking low bit rates. The TVs already support this because it is based on ABR technology.

ABR – Available Bit Rate – encoded content is delivered in profile ladders, used in all streaming to homes today.

VVC – Versatile Video Codec – the latest entrant to the ISO/IEC coding standards, promising 50% better than HEVC

EVC – Essential Video Codec – another "lower cost license" codec to compete against VVC but not likely to have the same amount of performance improvement over HEVC

Moving from Rec 709 to Rec 2020
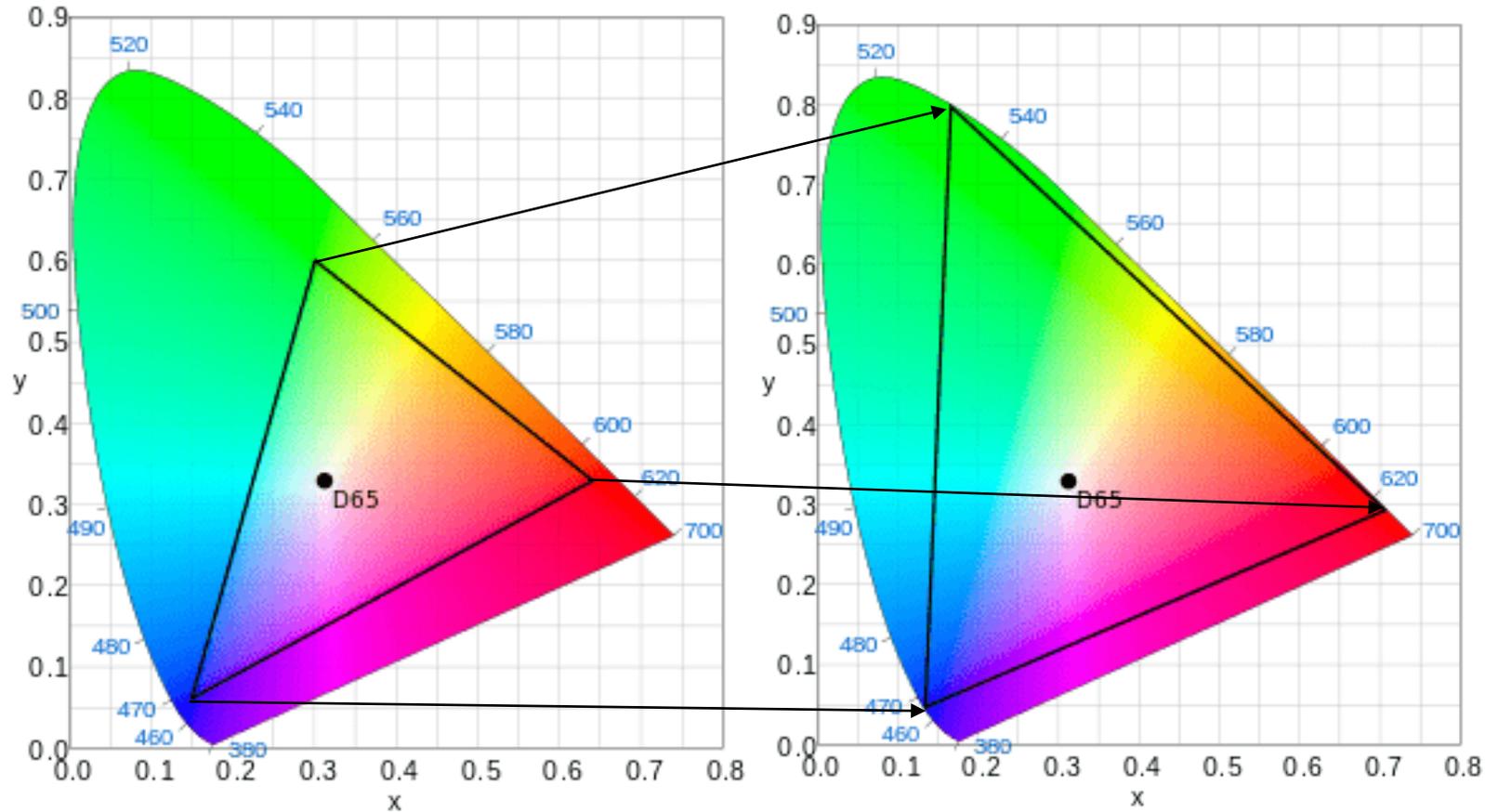
The color volume increase is a boost in color accuracy providing nearly 120% increase to more accurately map into 10 bit color. MPEG 2 was 8 bit and why the move to 709 color from NTSC 601. With the addition of UHD profiles in the ATSC 3.0 specification, we wanted to include more color accuracy and when coupled with HDR technology, the picture quality goes way up.

Source
Wikipedia

HYBRID Delivery

SOME THOUGHTS ON SYSTEM PERMUTATIONS

HYBRID Delivery of ATSC 3.0

SINGLE FREQUENCY	MULTI FREQUENCY	HYBRID ASSUMPTION
Single High Tower - High power, also publishes duplicates of all programming to a CDN.	2 ATSC Carriers bonded together to make one large virtual pipe. Requires multi tuner TV and Internet.	ALL FLAT SCREEN TV RECEIVERS HAVE A TUNER TO RECEIVE BOTH ATSC 1.0 OR 3.0 **AND** AN ETHERNET CONNECTOR
Multi tower - SFN with 2 or more TX also publishes boutique channels to a CDN.	ATSC 3.0 services bonded with 4G LTE, 5G or CBRS delivery, enabling cell phones.	
Moves operation into the cloud and feeds 10's of towers spread out geographically from the cloud and the CDN.	ATSC Translator collocated with WISP or CBRS, or customers ISP like Starlink™.	

1.0 to 3.0 Transition

WHEN	2021-22	2022-23	2023-24	2024-25
Markets greater than 100 (Lansing)	Only a unique cases will consider starting in 3.0, the ATSC 1.0 landscape will continue to deploy DOT 2.	More deep blue areas will show up on the map, Canada station issues will need to be resolved.	More light blue areas will show up on the map	More gold areas will show up on the map reaching farther into rural areas
Markets greater than 50 (Green Bay)	Coming soon… the issue will be along the northern border and we don't know all their plans yet	More light blue areas will show up on the map	Channel Share – will increase to 40% of channels broadcasting 3.0	Channel Shares – the percentage of channels will increase above 70%
Markets greater than 20 (Milwaukee)	Chicago has announced (dark blue) which will influence other large markets	Channel Shares will start service to launch 3.0 broadcasting	Multiple Channel Shares getting us to 70% of the US covered in 3.0	More than half of all stations will start to twilight their 1.0 operations, ending channel shares

Connecting with the Broadband Segment

The ATSC 3.0 standard supports <u>a direct connection from the TV station to a connected TV through an ISP to a CDN.</u>

DASH packager delivery is Unicast over TCP into an origin server at the CDN for Internet delivery – <u>They know each IP address</u> as they are directly connected with the ISPs

The feed from broadcasters to a CDN will integrate some combination of DRM and watermark technology

The TV->CDN delivery is the next big step in broadcast evolution

Broadcasters can *publish* their channels with the same or different profiles, different service layers OR with completely different products alternate views, ad replacements, multiple audio, different resolutions, entitlements, etc.

Most... (but not all)

| ATSC 3.0 Products run on Intel appliances	Pro encoders sold today support ATSC 1.0 and 3.0	All new video production runs over Ethernet...
• Servers "boot up" very differently when compared with ASIC hardware • Servers already support for 10-GbE ports	• **Harmonic** has completely converted to "pure software" to support virtual environments... • Bare metal, VMware, Docker, natural hybridization, cloud work flows, SaaS, VPC, etc.	• Coax video production plant is becoming the new island • Everything is starting to look exactly like a data center with "some SDI" • Wireshark is your friend

What's Next

At the end of …

◦ 2021 – more work in DRM and HDR plug fests will continue into next year, number of households reached will top 75% of US

◦ 2022 – cloud-based delivery solutions will continue to grow in support of more robust edge delivery closer to the TX, Hint: the Olympics

◦ 2023 – The tipping point in number of broadcasters running 3.0 and number of TVs sold with 3.0 tuners will occur

◦ 2024 – The majority of all broadcast will be running in 3.0 mode, it's hard to predict when exactly… politics and Olympics are involved

◦ 2025/6 – Some of us will be headed towards retirement

   ◦ Reminder - The moon has 1/6th gravity (two words, Moon Golf)
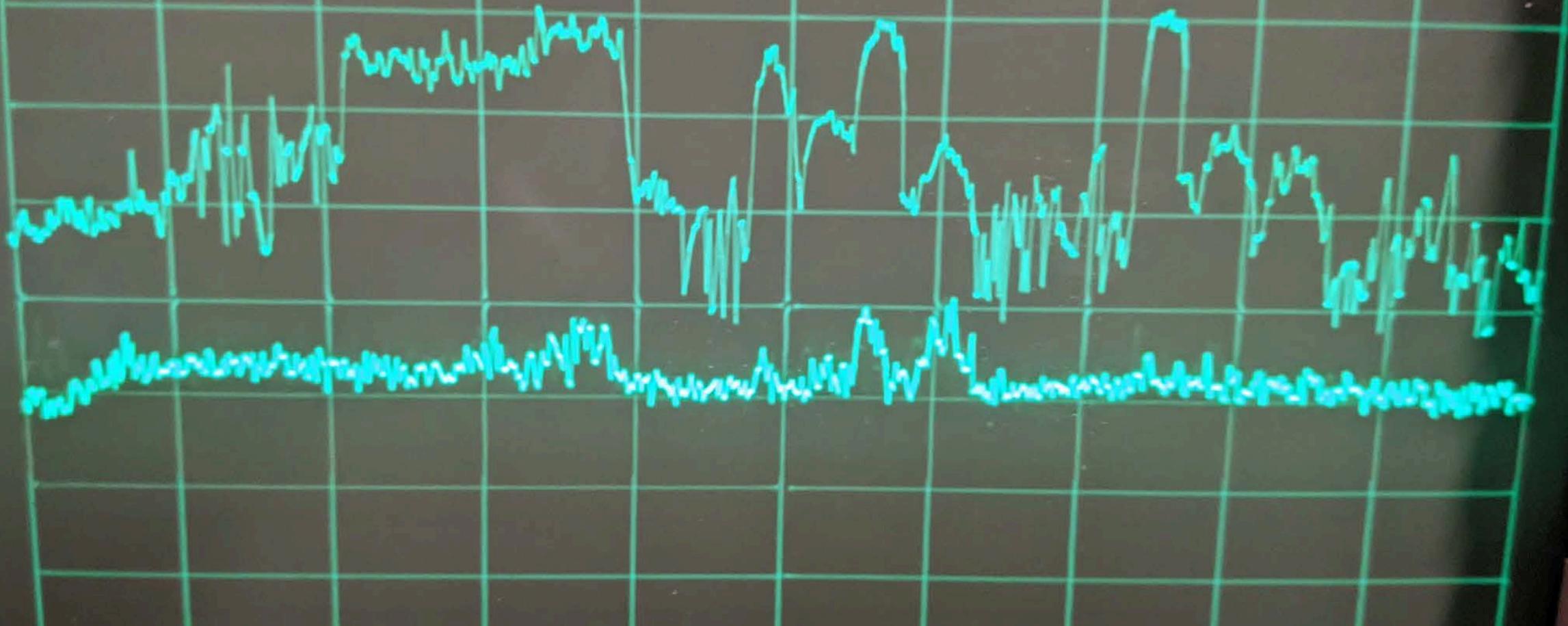
Summary

Main Points

Dirty air chains create heat in a mask filter. This robs performance which is not going out the antenna.

When picture quality is reduced, the stress on the statmux pool will increase, moving to improved codec technology will reduce this pressure but increase commercial issues

New Technology in the TVs will make your pictures look "spectacular", provide more choice and functionality, help the industry move forward

ATSC S41 Committee started work on the NPP for adding VVC codec to the standard in support of 8k resolution and point cloud encode technology

Broadcast advertising with a BACK CHANNEL creates a **10 fold increase** in advertising revenue

Thank you.

Joel Wilhite – Harmonic Inc.

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