ATSC 3.0
An Overview

SMPTE NEW ENGLAND SECTION MARCH 17, 2021

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CHAIR ATSC TG3

NEXTGENTV

POWERED BY ATSC 3.0

ATSC 1.0 Standard

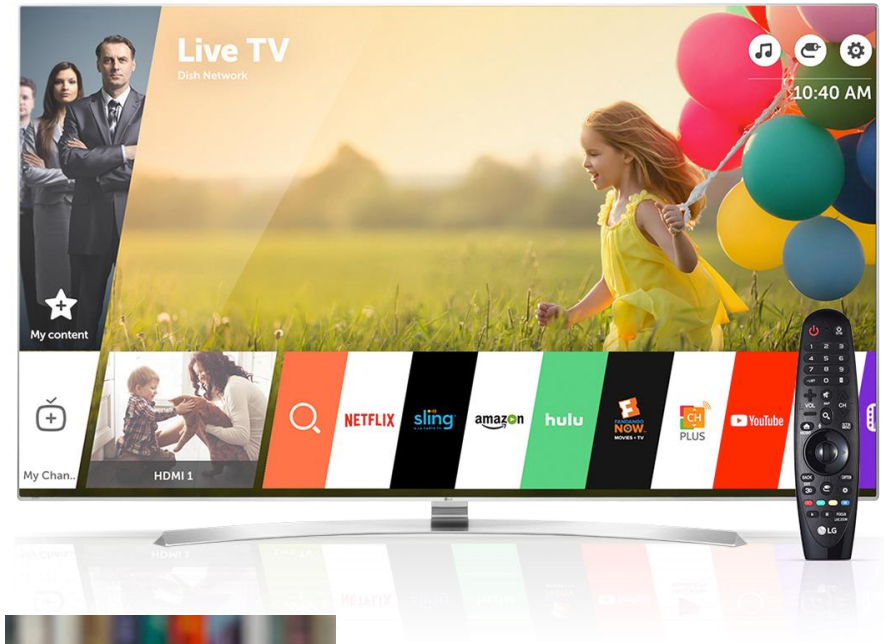
ATSC 1.0 (A/53)

- Digital TV broadcasting standard
- High-definition video
- Multicasting capabilities
- 5.1 digital surround sound
- Electronic program guides
- Closed captioning services
- Extensibility

DTV was revolutionary in 1995!

…Now 25+ years later…

Today: Rapidly Advancing Technologies



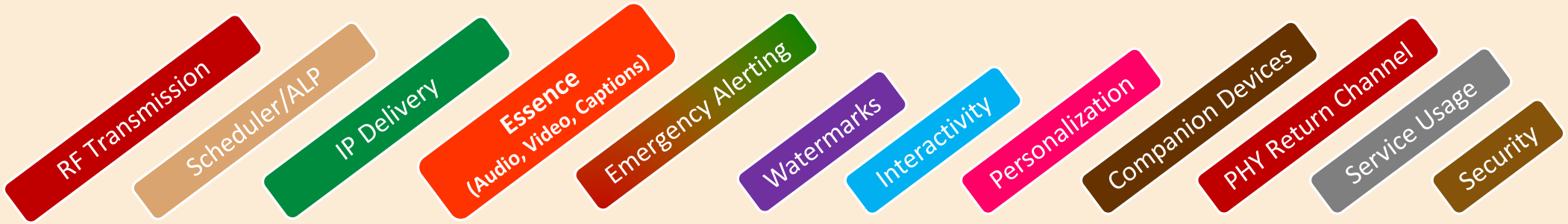
- OTA viewership is growing
- OTT services and usage are growing
- Mobile viewing continues to increase
- The cord cutting / shaving / nevers are changing the TV marketplace dynamics
- On-demand viewing is an assumed feature
- Digital advertising is increasingly powerful
- Targeted advertising is essential today
- Consumers have become “app-centric”

Key Advancements in 3.0

- **Additional capacity** — More channels, more pixels
- **Better reception** — Indoor, vehicles, mobile
- **Hybrid OTA and OTT** — All IP-based system
- **Enhanced consumer experience** — Improved video and audio quality; Improved accessibility; Interactivity; Advanced emergency alerting
- **New business models** — Advanced advertising; PPV and subscription services; Service usage reporting; Datacasting

ATSC 3.0 Document Structure

✓ ATSC 3.0 "Parent" System Standard A/300 (Points to Each Separate Standard Document)



Individual Standards Documents

- ✓ Video Standard: A/341
- ✓ Audio Standard: A/342
- ✓ Captions & Subtitles: A/343
- ✓ Service Announcement: A/332
- ✓ Delivery, Signaling & Sync : A/331
- ✓ Link Layer Protocol (ALP): A/330
- ✓ Scheduler, STL & SFN: A/324
- ✓ PHY Layer D/L Standard: A/322
- ✓ Sys. Discovery & Signaling: A/321
- ✓ Companion Devices: A/338
- ✓ Interactive Content: A/344
- ✓ Application Signaling: A/337
- ✓ Content Recovery in Redistribution Scenarios: A/336
- ✓ Video Watermark Emission: A/335
- ✓ Audio Watermark Emission: A/334
- ✓ Security Standard: A/360
- ✓ Service Usage Reporting: A/333
- ✓ PHY Layer U/L Standard: A/323

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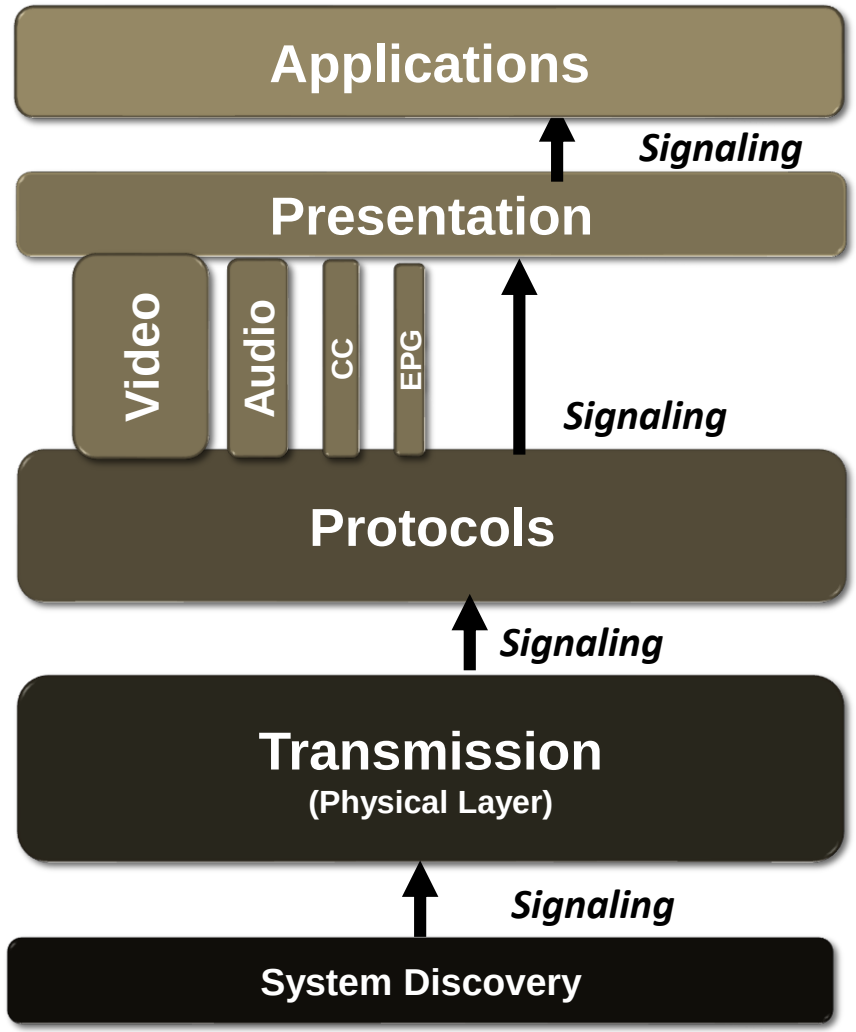
Overview - ATSC 3.0 System Layers

System Discovery and Signaling Enable Maximum Flexibility and Minimal Regulation



- *Smart TV "Apps"*
- *Screen is a web page*

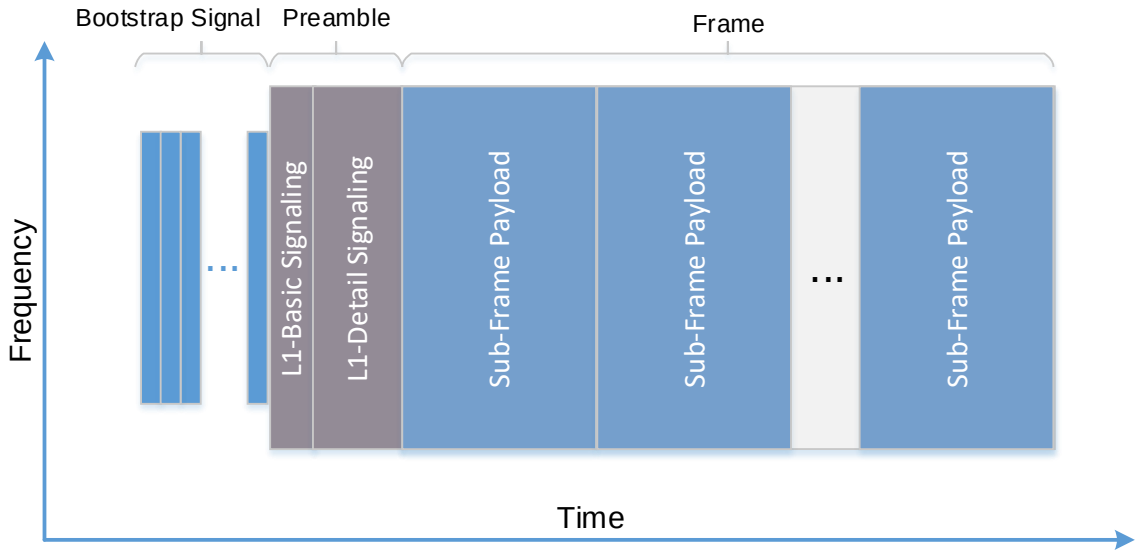
- *UHD*
- *HD & SD multicast*
- *Immersive Audio*

- *Internet Protocols UDP/IP*
- *ROUTE/DASH*
- *MMT/DASH*
- *ISOBMFF*

- *OFDM*
- *Physical Layer Pipes*
- *Layer Division Multiplex*
- *Protocol Signaling*
- *Channel Acquisition*
- *EAS Wake-Up*
- *Modulation Signaling*

Starting Point: Physical Layer

- **Extensibility / Flexibility**
  - Bootstrap (A/321) – a-priori information
  - Possible to evolve system/physical layer
    - Announces technology used in each frame
  - Layers signal technologies to layer above
  - Allows graceful evolution over time

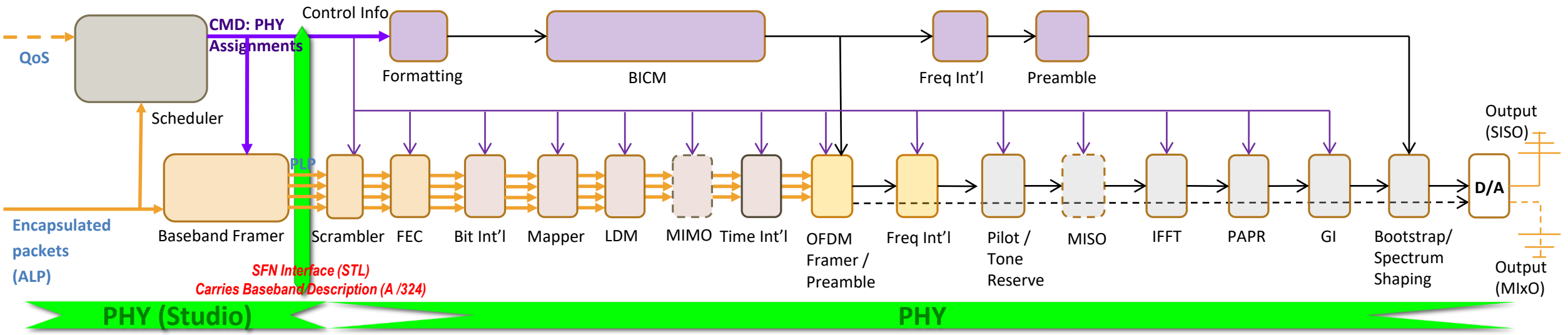


Bootstrap emission is the starting point for ATSC 3.0

- Robust synchronization
  - Service discovery
  - Coarse time, frequency acquisition
  - 4.5 MHz bandwidth
  - Receivable at <–6 dB SNR (with FER = 1E-2)

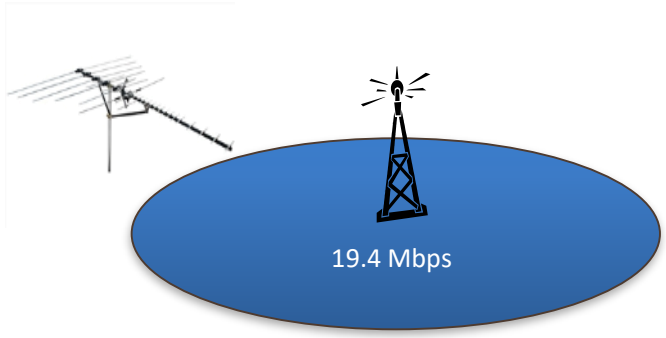
- 24 signaling bits
  - Sampling frequency
  - Channel bandwidth
  - EAS wake-up
  - Preamble selection
- Preamble frame control
  - Basic / detail

Physical Layer Architecture



Transmission

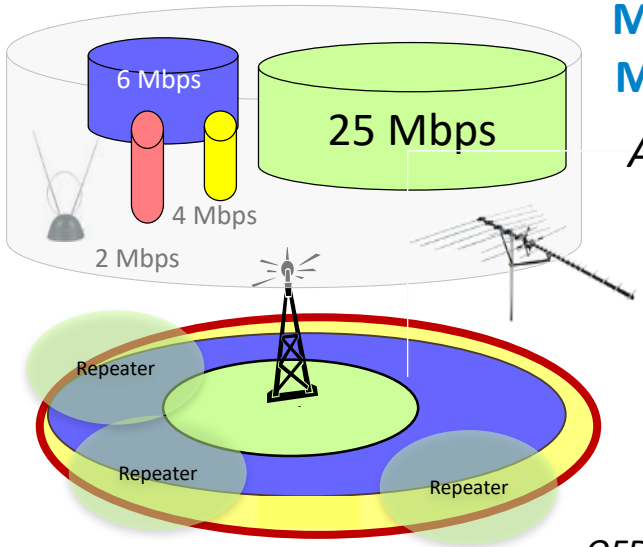
ATSC 1.0



8-VSB

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

ATSC 3.0



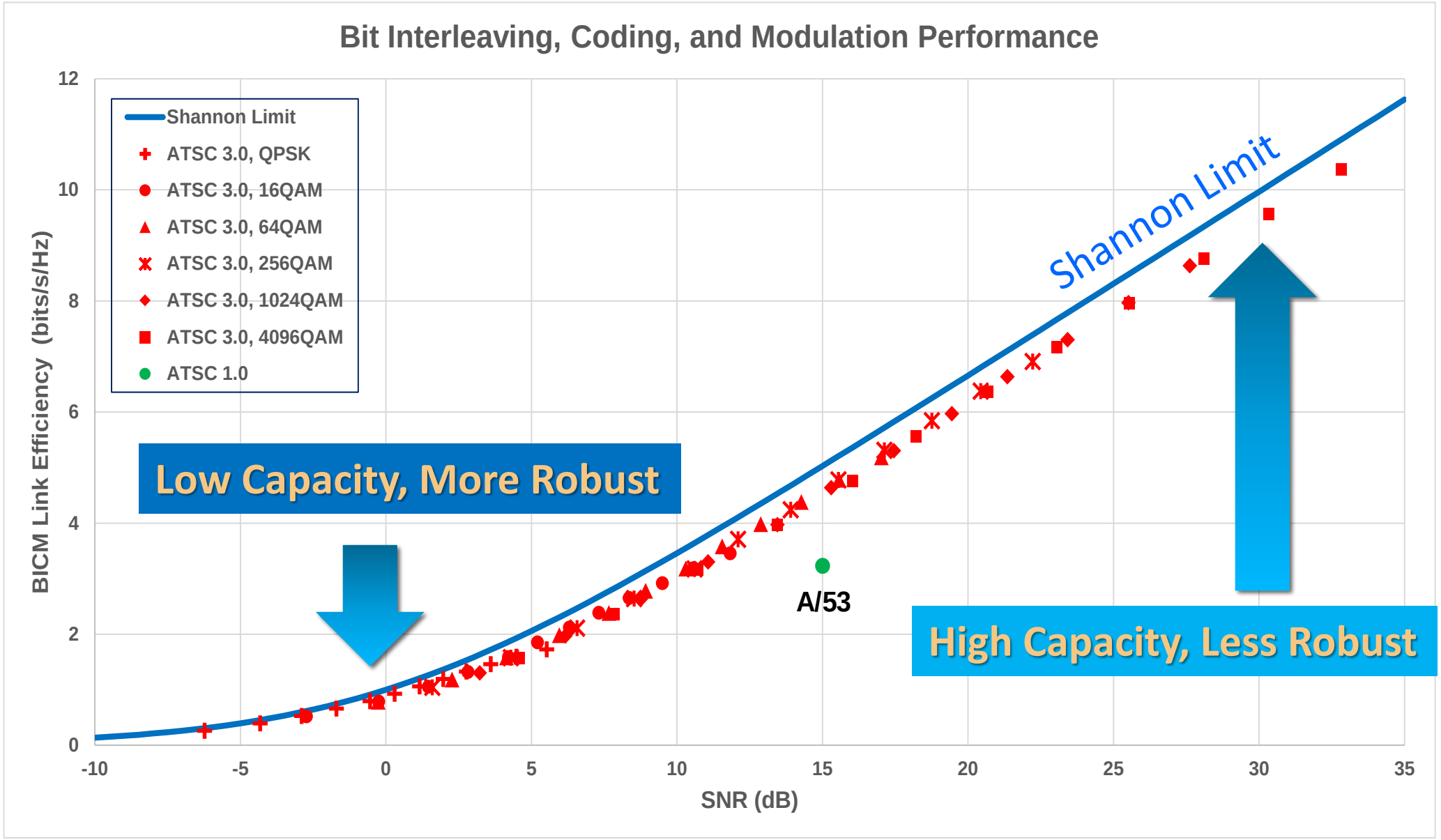
More Bits To More Places

AND

OR

OFDM with 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
- Optional on-channel repeaters for robust indoor & mobile reception over entire DMA

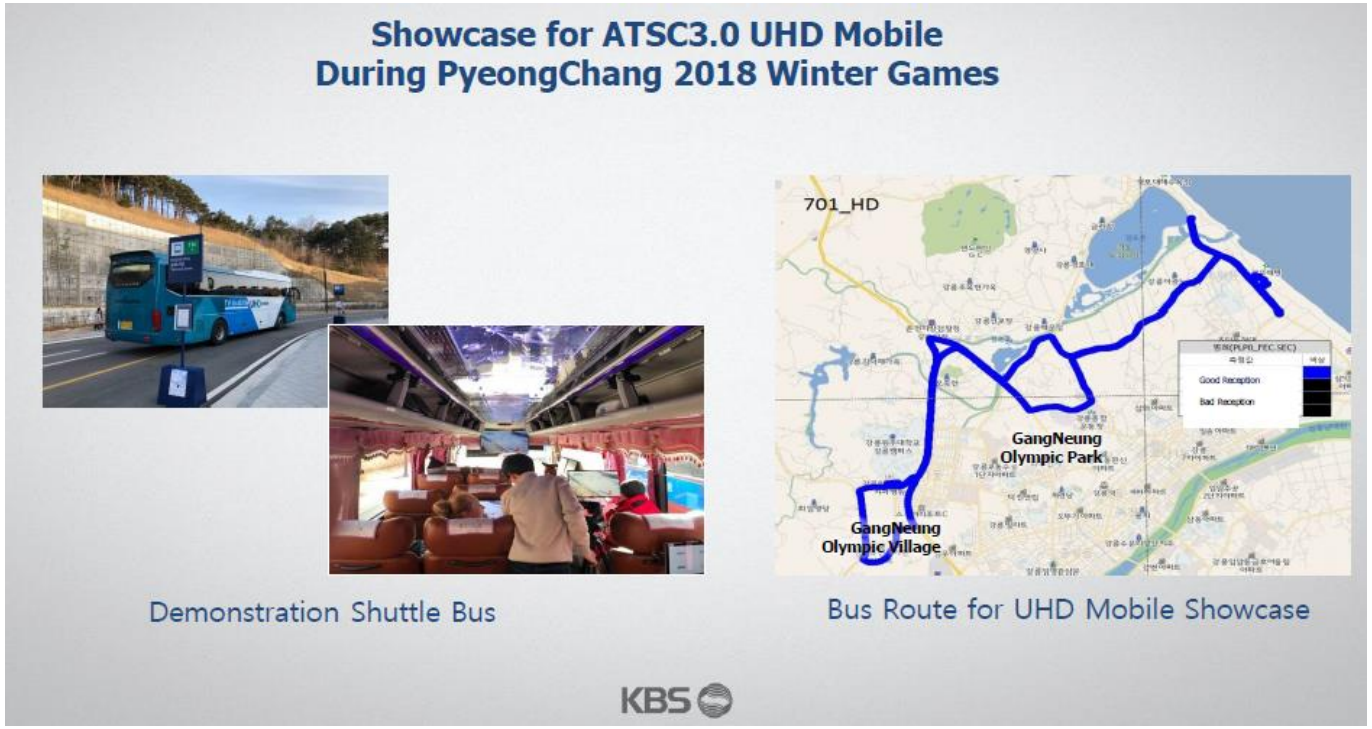

Bit Interleaving, Coding, and Modulation Performance
BICM Link Efficiency (bits/s/Hz)
SNR (dB)
Shannon Limit
ATSC 3.0, QPSK
ATSC 3.0, 16QAM
ATSC 3.0, 64QAM
ATSC 3.0, 256QAM
ATSC 3.0, 1024QAM
ATSC 3.0, 4096QAM
ATSC 1.0
Low Capacity, More Robust
High Capacity, Less Robust
A/53
Shannon Limit
0
2
4
6
8
10
12
-10
-5
0
5
10
15
20
25
30
35

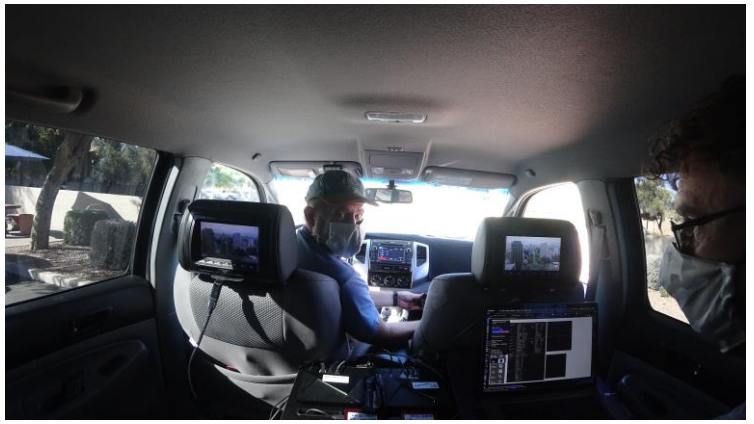
Example Scenario: Deep Indoor Reception & Mobile, Single Stick

- Single Station Mix Stationary - Robust/Mobile Services
- Two PLP's
  - 3 HD Service ~18Mbps, Threshold AWGN 17.0dB
  - 1 HD Robust/Mobile Video Services ~ 3M, Threshold AWGN 5 dB

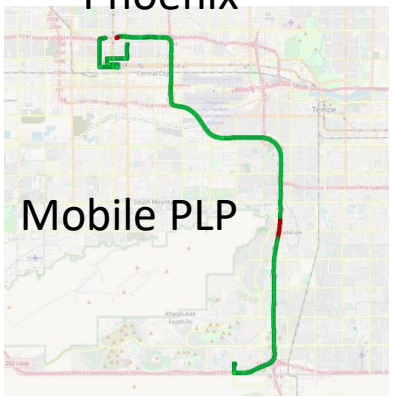
Parameter	PLP0 (Mobile)	PLP1 (Stationary)
RF Center Frequency	599	
Subframe	0	1
FFT Size	8K	16K
Pilot Pattern	6_4	12_4
Pilot boost	4	
Guard Interval	G5_1024 (148us)	
Preamble Mode	(Basic: 3, Detail: 3) Pattern Dx = 3	
Frame Length	155 msec	
# of Symbols	41	39
Frequency Interleaver	On	On
Time Interleaver	Hybrid 16 FEC Blocks 1 TI Block (51.1msec time spread)	Hybrid 63 FEC Blocks 2 TI Block (47.8msec time spread)
Modulation	16 QAM	256 QAM
Code Rate	7/15	10/15
Code Length	64K	
Contents	KFPH-CD (UniMas) test program	KTVW-DT(Univision), KPNX (NBC), KPHO (CBS)
Bit Rate (Mbps)	3.093	18.166
Required C/N (dB) (Single diversity, AWGN)	5.2	17.1

ATSC 3.0 Mobility

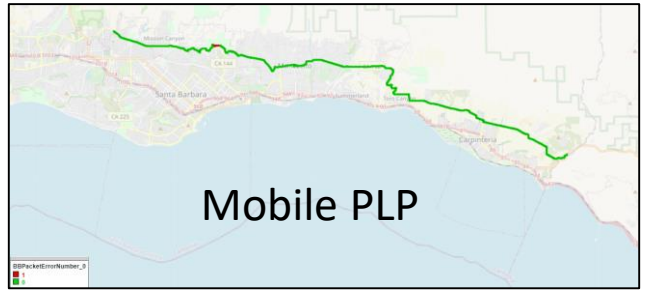




Phoenix

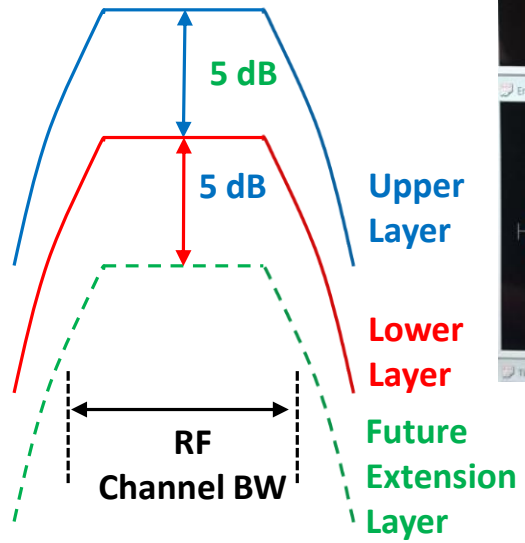


Santa Barbara

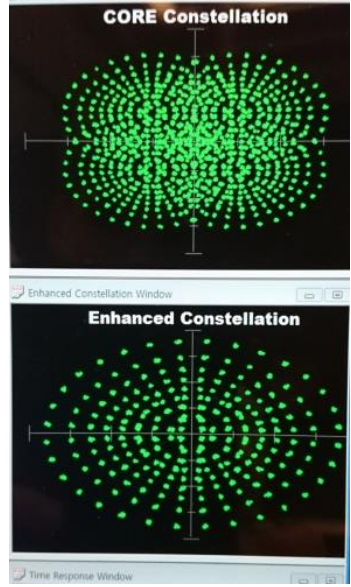


Layered Division Multiplexing (LDM)

- 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;
- For each LDM layer, **100% of the RF bandwidth and 100% of the time** are used to transmit the multi-layered signals for spectrum efficiency and flexible use of the spectrum;
- **Signal cancellation** can be used to retrieve the robust upper layer signal first, cancel it from the received signal, and then start the decoding of lower layer signal;

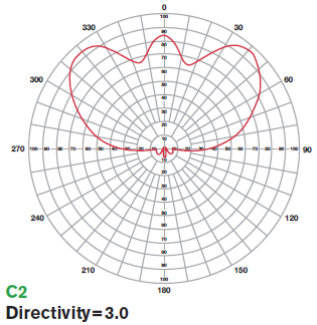


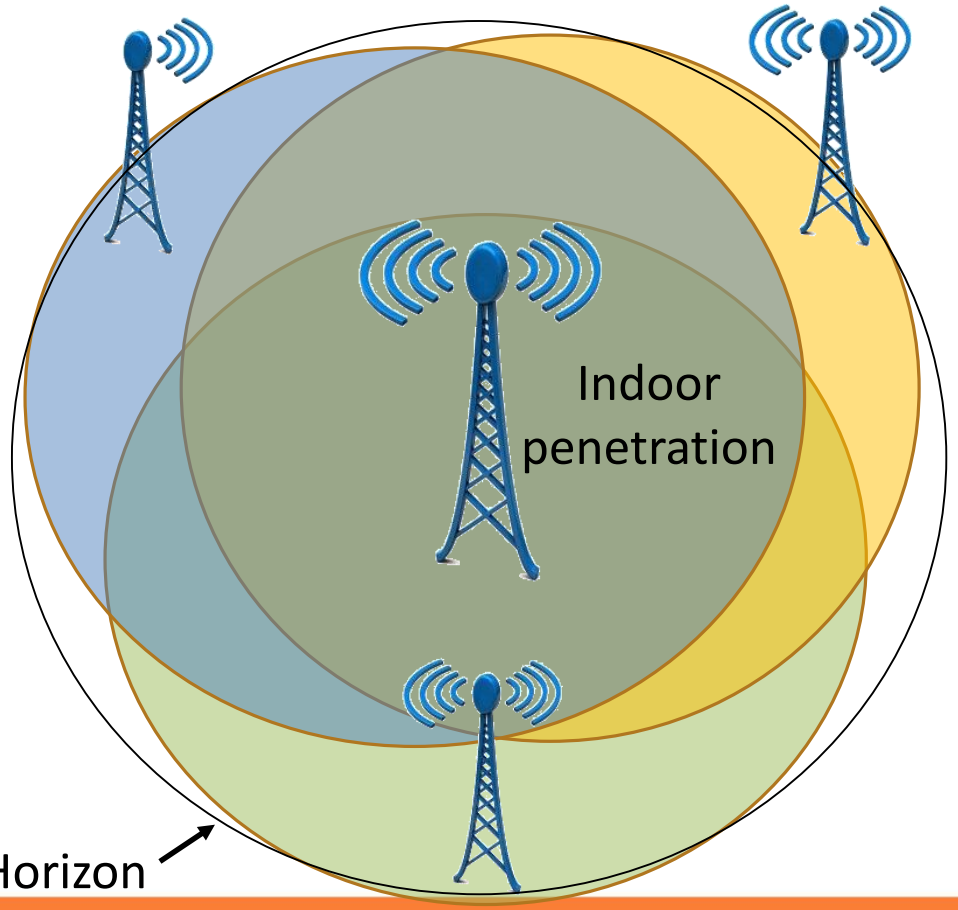
LDM overlay spectrum



- The **upper layer (UL)** is ultra-robust and well suited for HD portable, indoor, mobile reception. The **high data rate lower layer (LL)** transmission system is well suited for multiple-HD and 4k-UHD high data rate fixed reception.
- **Future Extension Layer (FEL)** can be added later with full backward compatibility.

Result - Better coverage & deep indoors via SFN

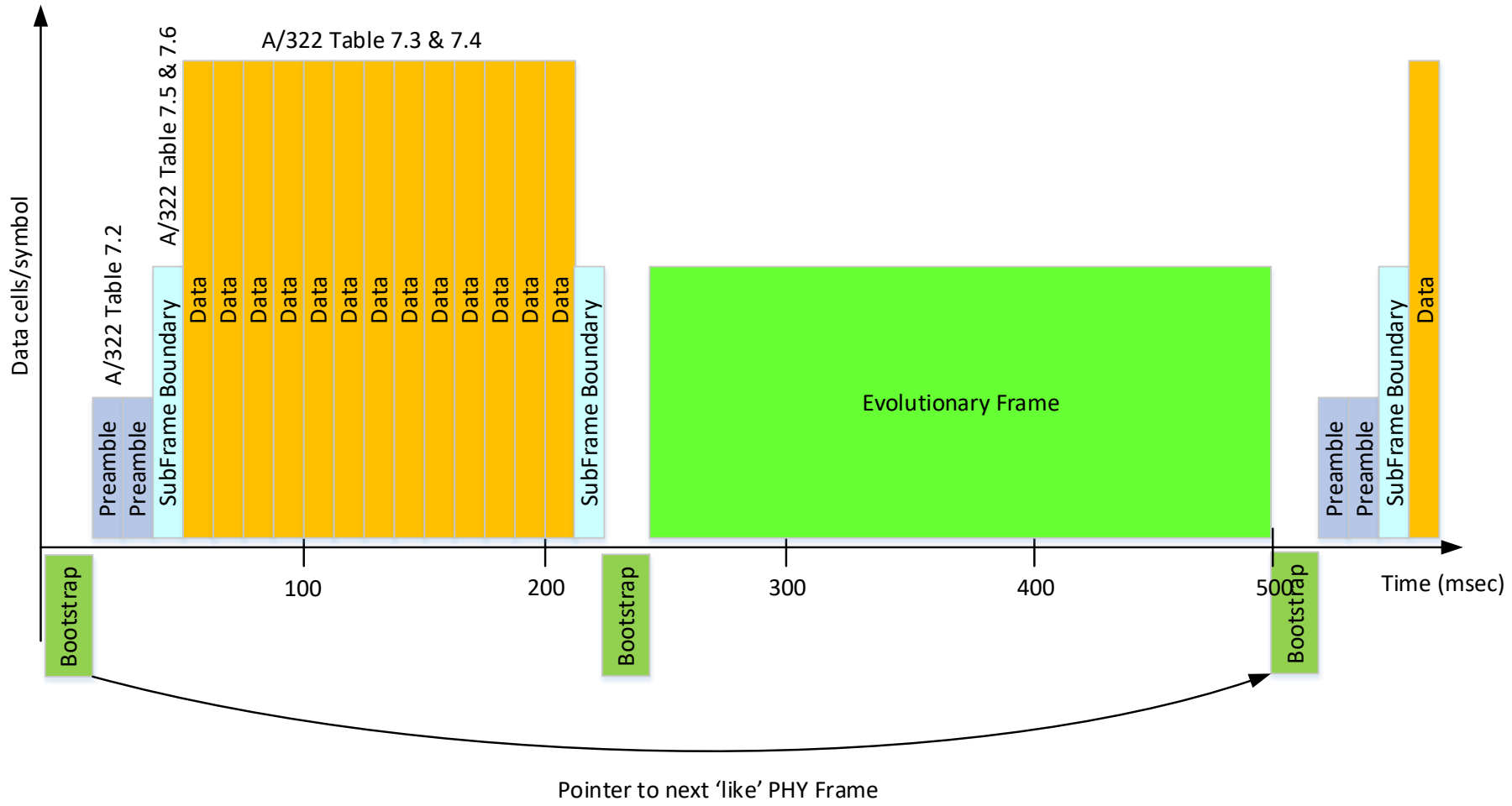




Multiple transmitters in a SFN can be used to extend coverage and add capacity by raising the SNR.

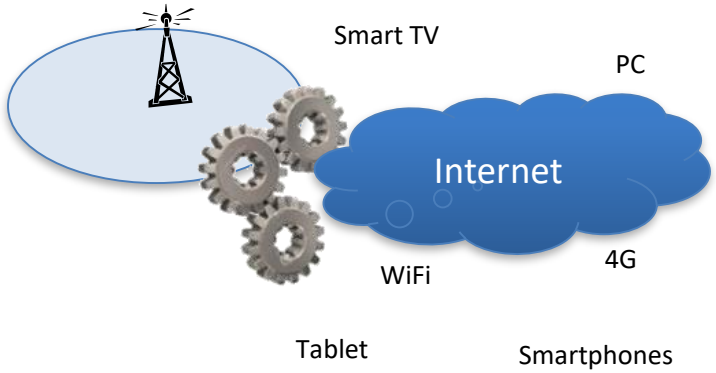
OFDM guard interval alleviates potential inter-symbol interference arising from multiple transmitters.

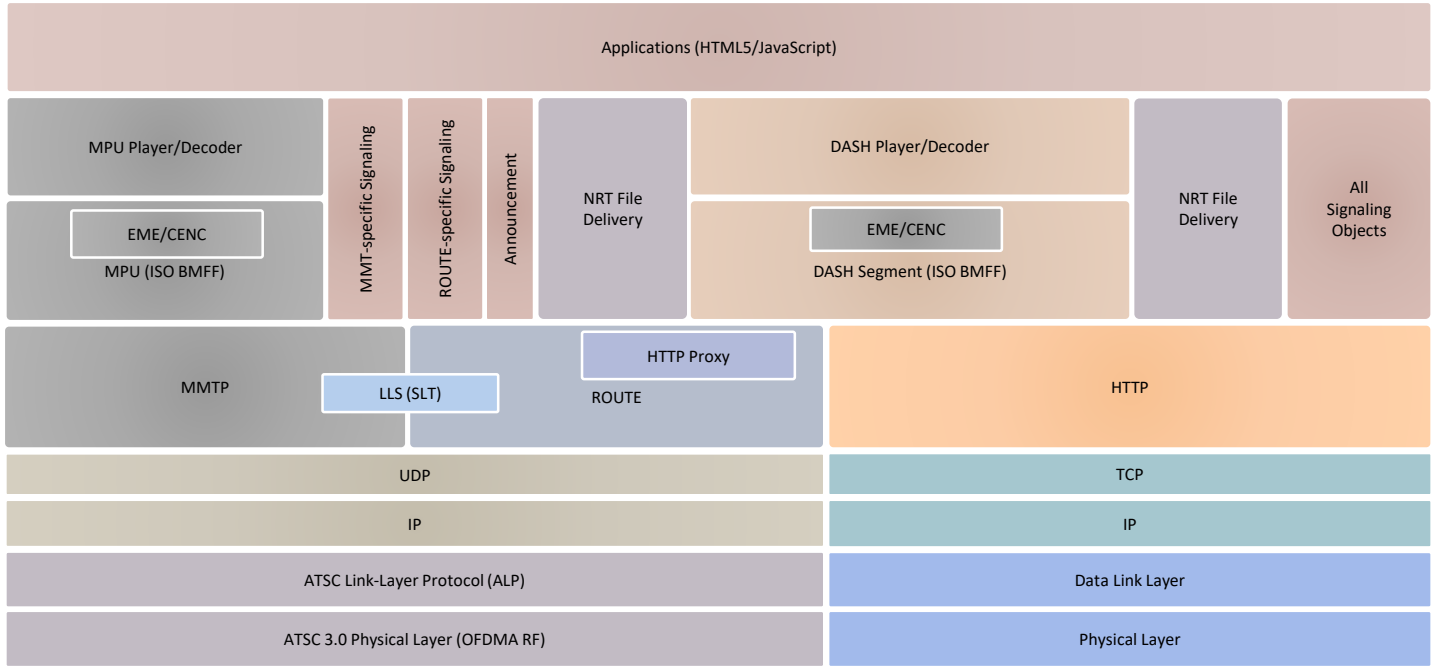
ATSC 3.0 PHY Frame Evolution Example

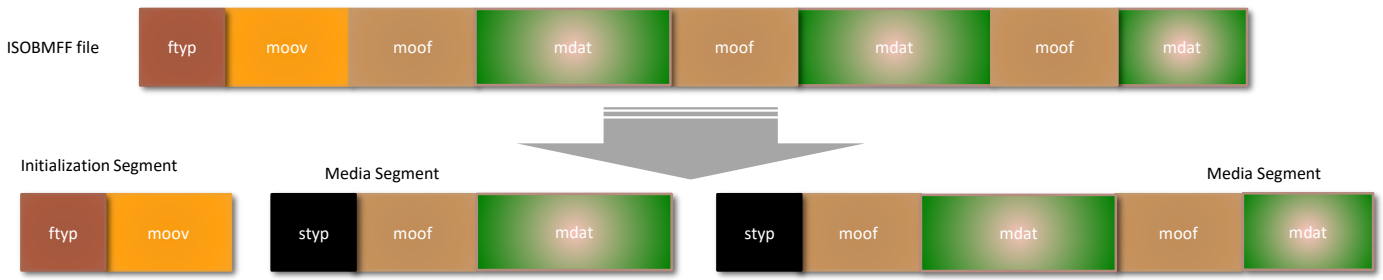


Protocols

- **Media Delivery**
  - Broadcast IP Transport
  - Segmented streaming delivery
  - Hybrid – combined broadcast & broadband delivery
  - Realtime & NRT







….meaning

Broadcasting no longer an independent silo

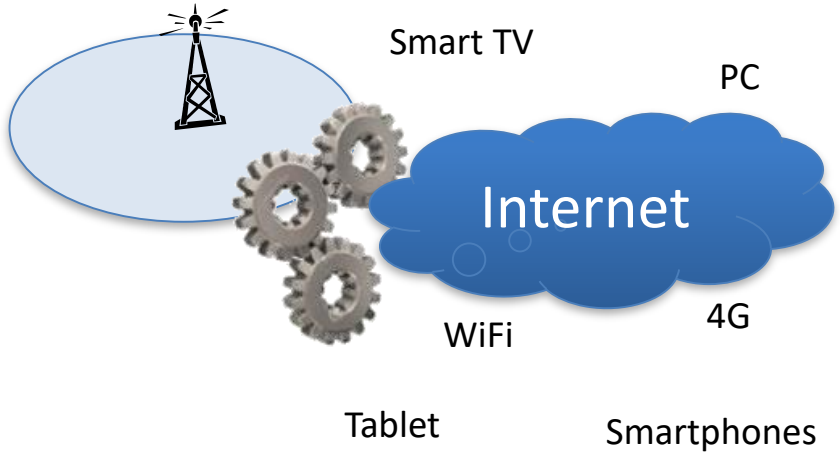
- Use of IP allows taking advantage of evolution speed of the Internet

Broadcast and broadband as peer delivery mechanisms

- Enables new types of hybrid services
- Ability to seamlessly incorporate niche content

Enable new business models

- Localized insertion of ads or other content
- New revenue model for broadcasters that has previously been available to only cable or IPTV operators
- Addressable advertising



ROUTE (Real-time Object delivery over Unidirectional Transport)

Real-time object delivery protocol that is agnostic to
and independent of the object's internal structure

Replacement for FLUTE as an application of Asynchronous Layered Coding (ALC) protocol for broadcast services delivery

Key features

- Single transport protocol for linear TV, NRT files and signaling metadata
- Enables early playout of Segments ("MDE" mode)
- Flexible packetization for playout timing and transport optimized delivery
- "Extended FDT": out-of-band and advanced delivery of file descriptors to enhance reliability of object recovery, and reduce signaling overhead
- ROUTE is very similar to and is based on the 3GPP MBMS download delivery protocol

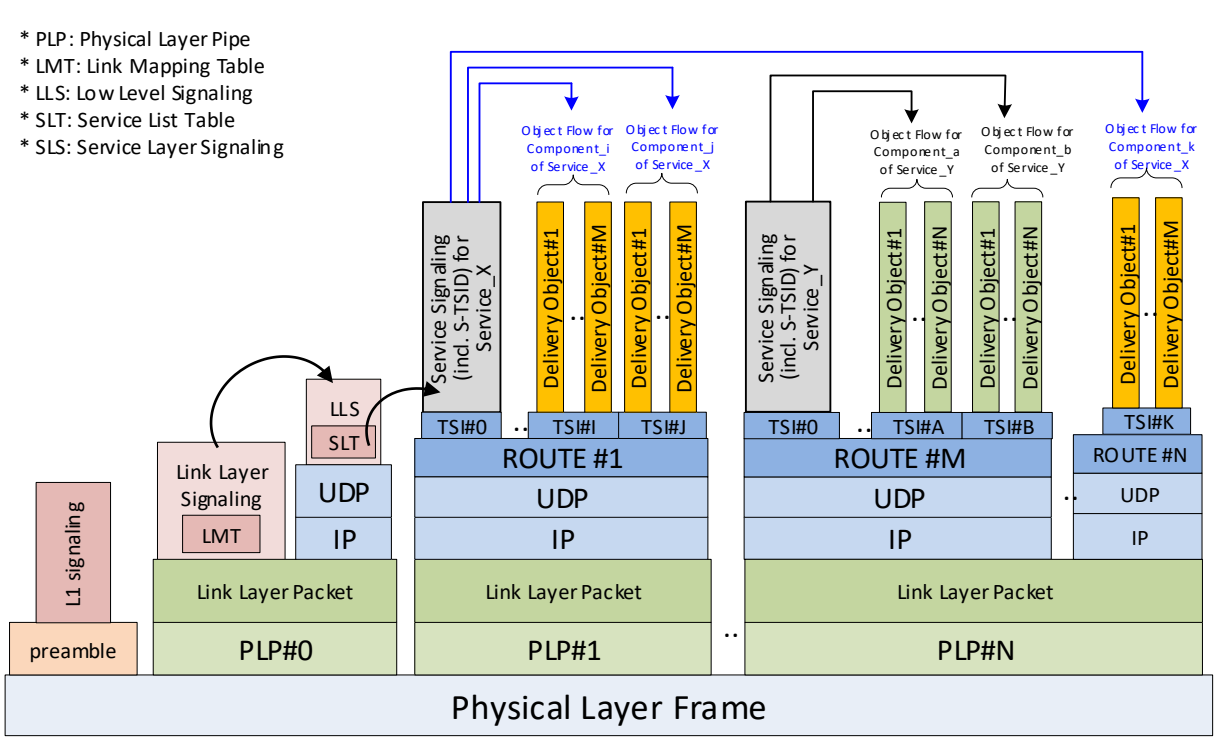
MPU (Media Processing Unit)

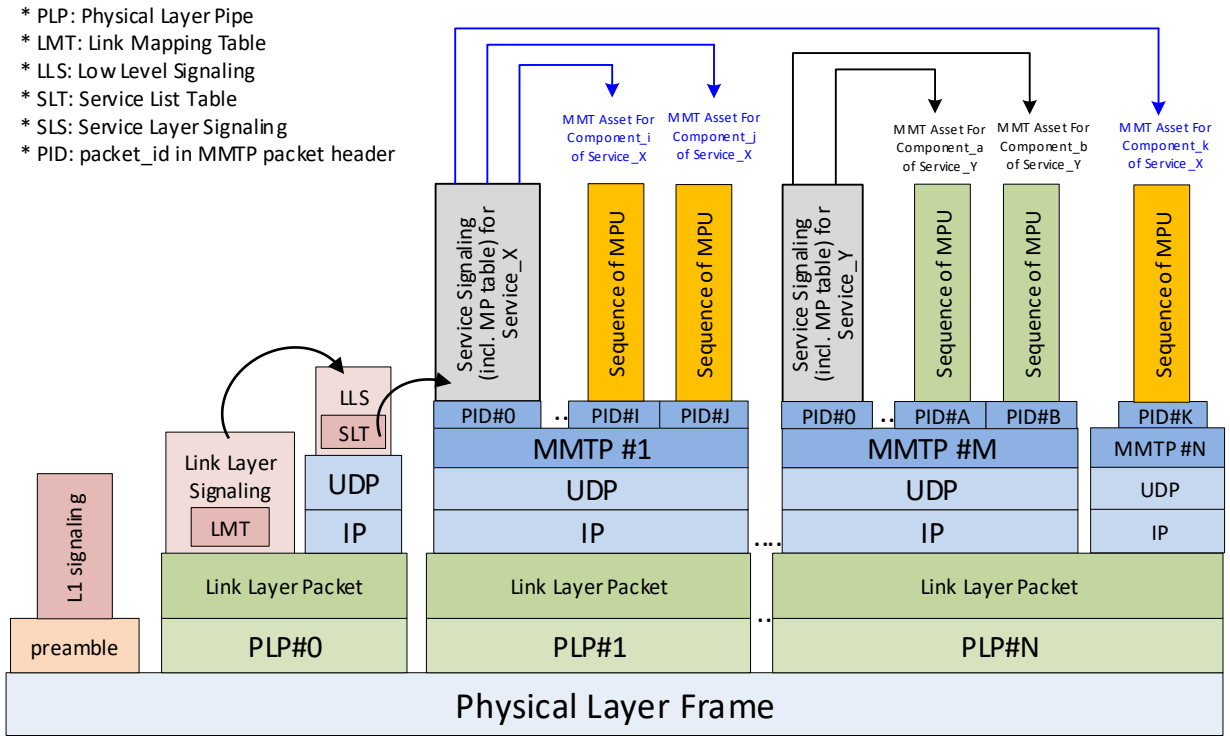
MPU is defined in MPEG-H Part 1 (ISO/IEC 23008-1) MPEG Media Transport (MMT) standard

An MPU is an ISOBMFF file with the “mpuf” brand

- ‘mmpu’ box provides globally unique identifier
- A single media track is allowed
- Sample data must be in decoding order
- Self-contained (all media sample can be decoded without any further information)
- Optional hint track supports media aware packetization

Hierarchical Signaling (ROUTE/MMT)





ATSC 3.0 Security

System-wide security is a critical function today for any Internet-connected device
- A TV set that can be hacked? Yes!

Signed Signaling Tables and Apps
- Receivers can validate the source of the emission

Content protection for high-value programs is very important
- Digital Rights Management (DRM) is an essential requirement for content providers
- Enables new business models such as:
  - Subscription services, “Freemium” services (register to watch), Pay-per-view…
- Based on CENC (CTR, CBC modes)

Security enables new business models for ATSC 3.0
- Subscription services
- Monthly fee for access to the service
- “Freemium” (i.e., user registers and then content is free)

Subscription options for alternate components
- Custom views; e.g., pay for “dashboard cam” video in an auto racing event
- Pay-per-view programs
- HD free-to-air, UHD subscription service

ATSC 3.0 Video

Resolutions up to 3840 × 2160

Spatial scalability (SHVC)

High Frame Rate

- Up to 100, 120, 120/1.001 (plus lower framerates)
- Temporal sub-layering enables backward compatibility
- Plus temporal filtering for optimizing both the SFR and HFR pictures

High Dynamic Range

- PQ & HLG transfer functions (plus SDR)
- Metadata for PQ

Wide Color Gamut

- Wide Color Gamut BT.2100 (plus BT.709 for SDR)
- $Y'C_BC_R$ non-constant luminance
- IC_TC_P constant luminance (for PQ)
- Full Range coding (for PQ)
- SL-HDR1 for delivering SDR/709 stream that SL-HDR1-capable decoders can render as HDR/2020

ATSC 3.0 Audio

Two Next Gen Audio Systems

- MPEG-H
- Dolby AC-4

Dialog Enhancement

User-selectable Audio Tracks

- Alternate languages
- Alternate sports commentary
- Video description services

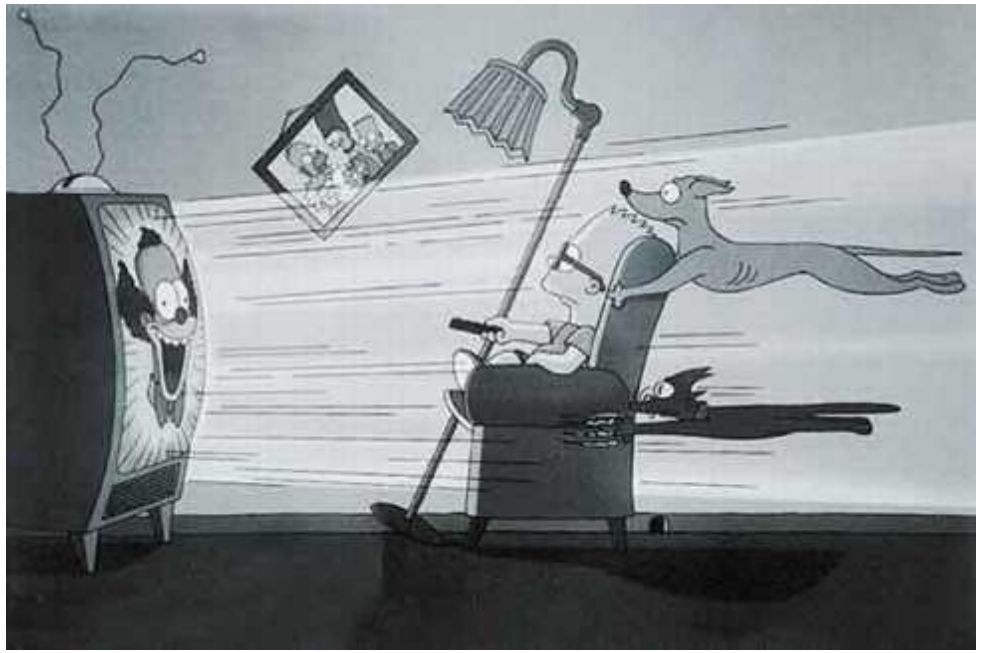
Immersive Sound

- Sensation of sound comes from all around and above the listener
- Works on soundbars, headphones, and a variety of speaker configurations

Dynamic Range Control

Improved Coding Efficiency

- Four complete presentations can be sent at ~384kbps
- E.g., English and Spanish dialog with English and Spanish VDS



Applications

Internet Experience
Personalized & Dynamic

ATSC 1.0

- Pictures, Graphics and Sound are “burned in”
- Same experience for entire audience

ATSC 3.0

- HTML5/Internet overlay graphics – liaison with W3C
- Hybrid delivery - merge broadcast & internet
- Dynamic Ad Insertion
- Interactivity, enhanced story information
- Synchronized second-screen applications
- Audience Measurement capabilities

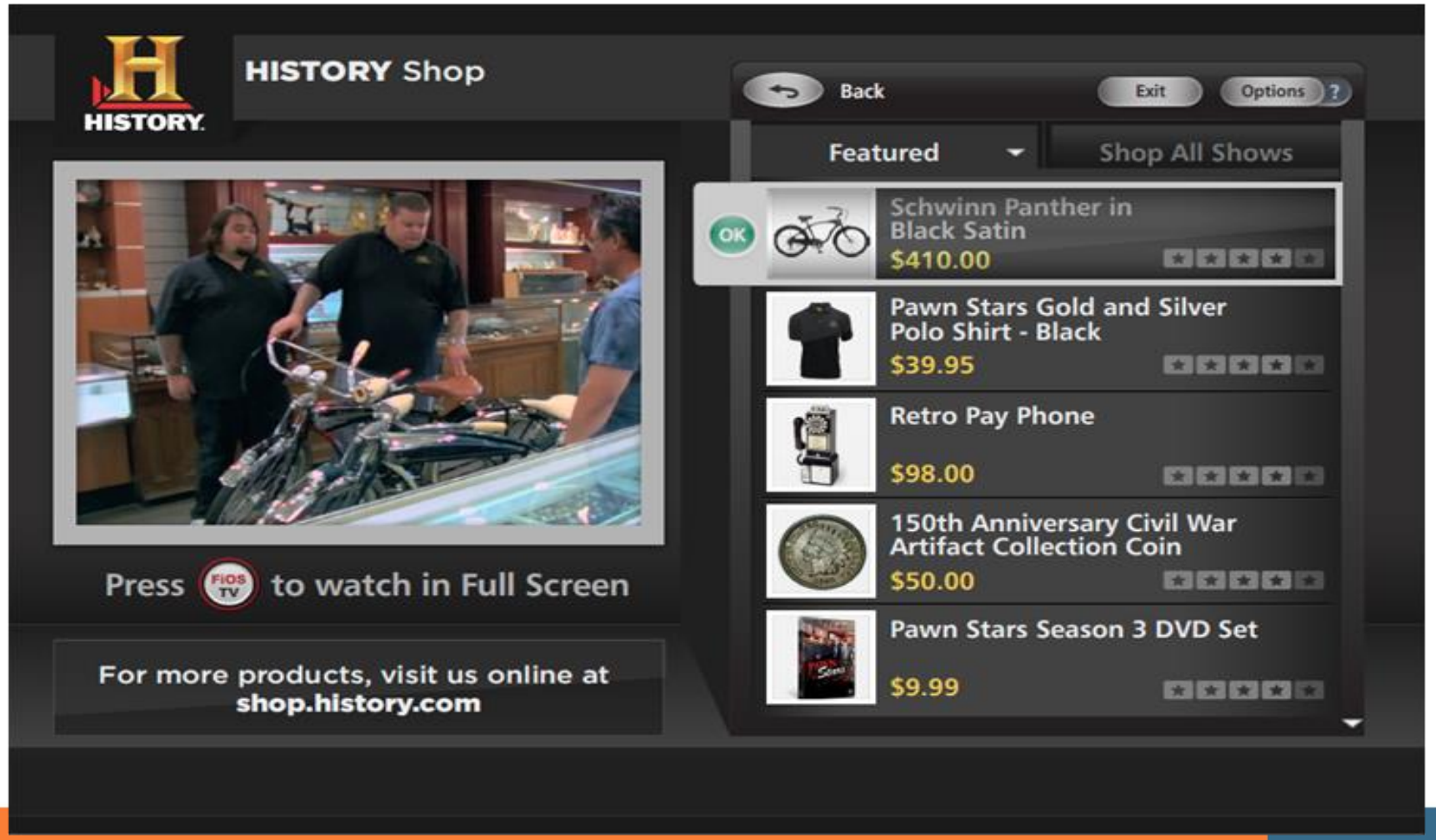
ATSC 3.0 Interactivity

The system is based on ***standard web technologies.*** It works in a browser.

- Describes the conceptual application operating environme
- Standard W3C User Agent – HTML5, CSS & JavaScript
- Supports seamless, secure delivery of interactive content from broadcast and broadband
- Provides a separate, unique context for each application
- Defines a WebSocket API to manage the receiver features

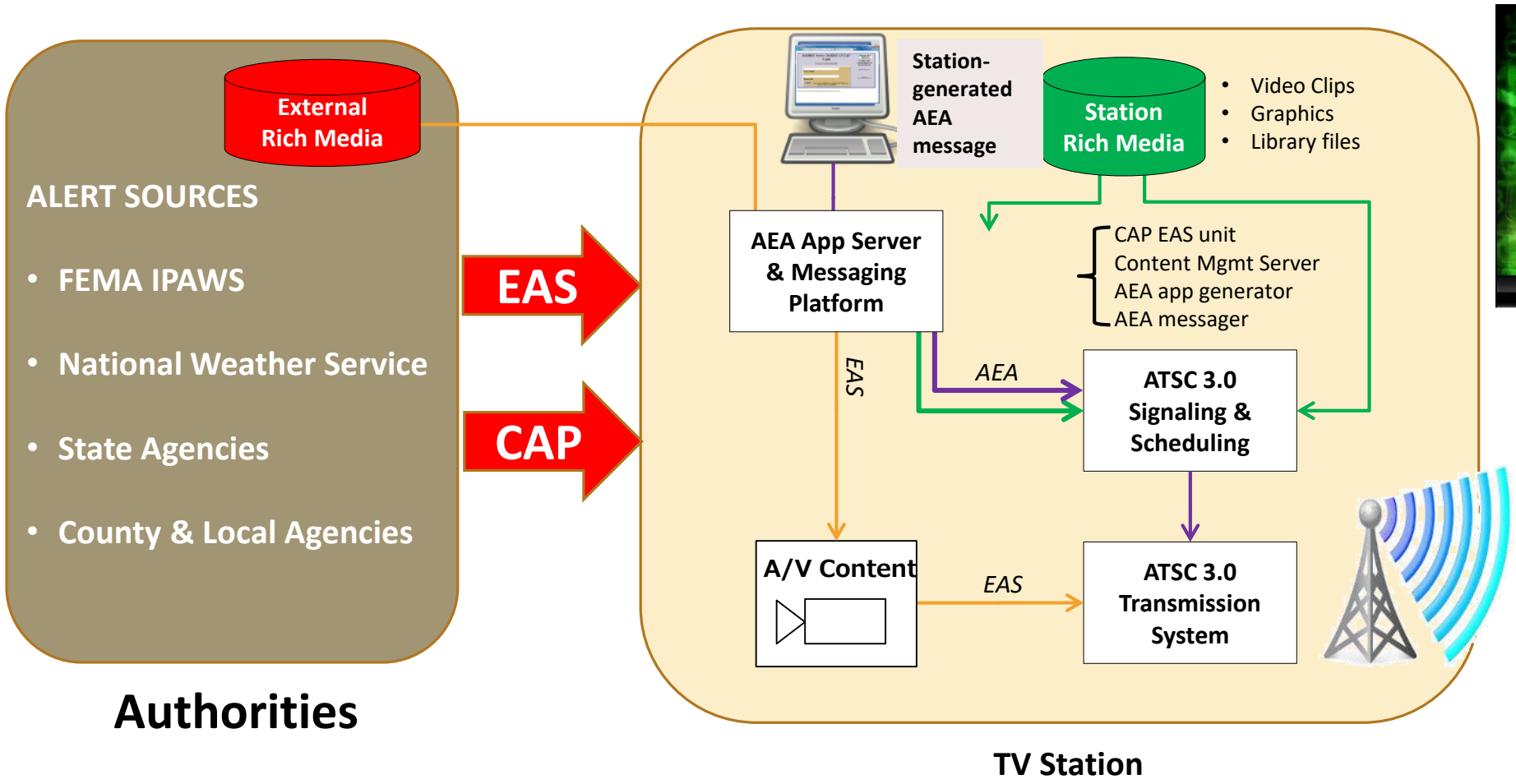
New business opportunity via interactive shopping

Linear Program



Sale Items

ATSC 3.0 Station Architecture with AEA



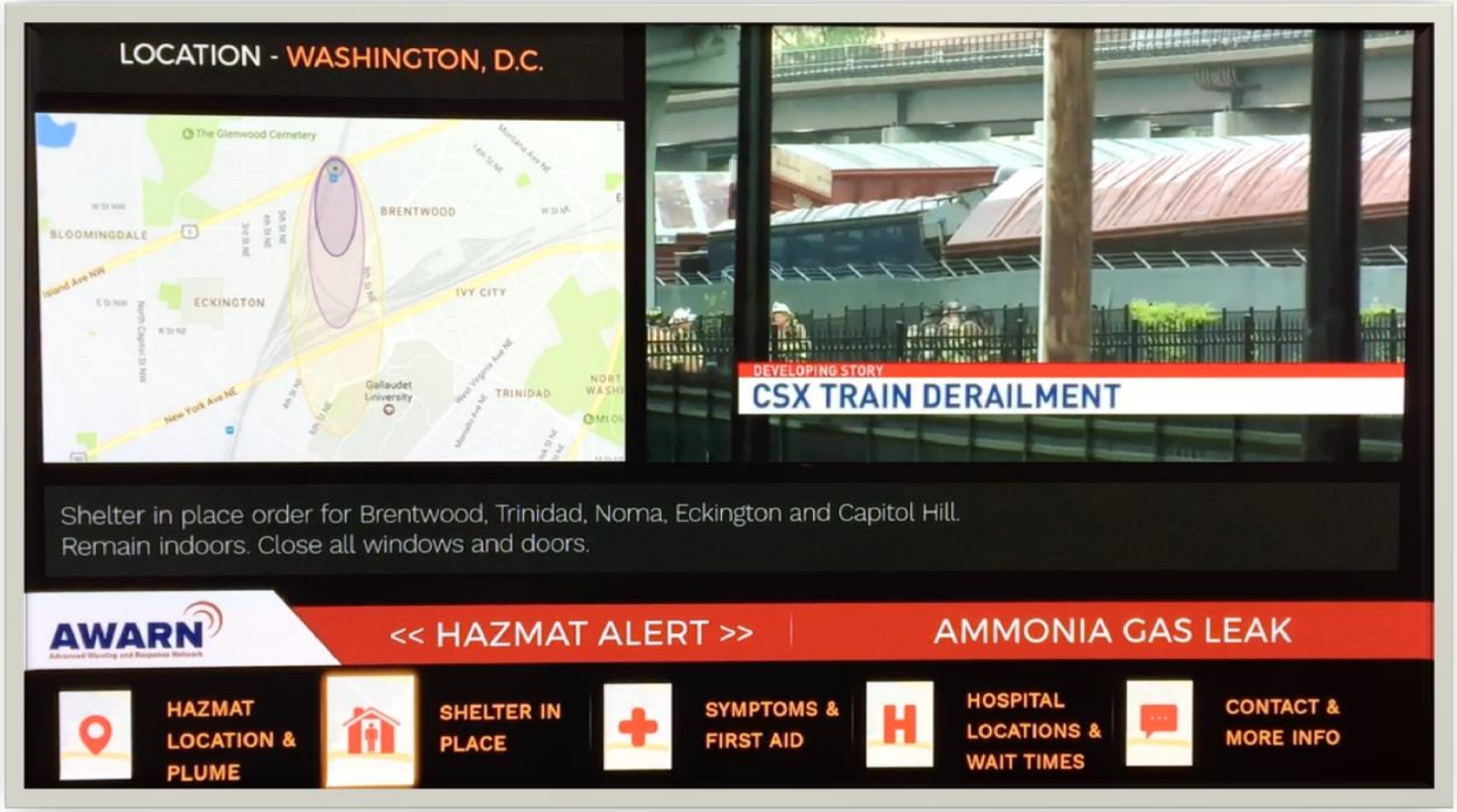
Authorities

TV Station

Audiences

ATSC 3.0 Advanced Emergency Information

- Deliver rich media such as video, web pages, etc.
- Target messages by geo-location and more
- Update or recall messages as needed



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Accessibility Features

ATSC 3.0 brings new public service capabilities

- Robust audio and closed-caption transmission, even when picture fails
- Improved audio intelligibility for hearing impaired
- New features for improved dialog / narrative intelligibility (track-specific volume control)
- Continued support for video description services

ATSC 3.0 feature set supports

- Visually Impaired (VI)
  - Video Description
- Hearing Impaired (HI)
  - Closed Caption
  - Closed Signing
  - Dialog Intelligibility
- Emergency alerts and messaging
  - Emergency crawls and audio tracks

ATSC Supporting Deployments and Evolution

Recommended Practices
- Best practices for configuring a system
- Methods for achieving different business goals and use cases

Plugfests, early deployments and implementation teams
- Feedback hones and improves the Standards

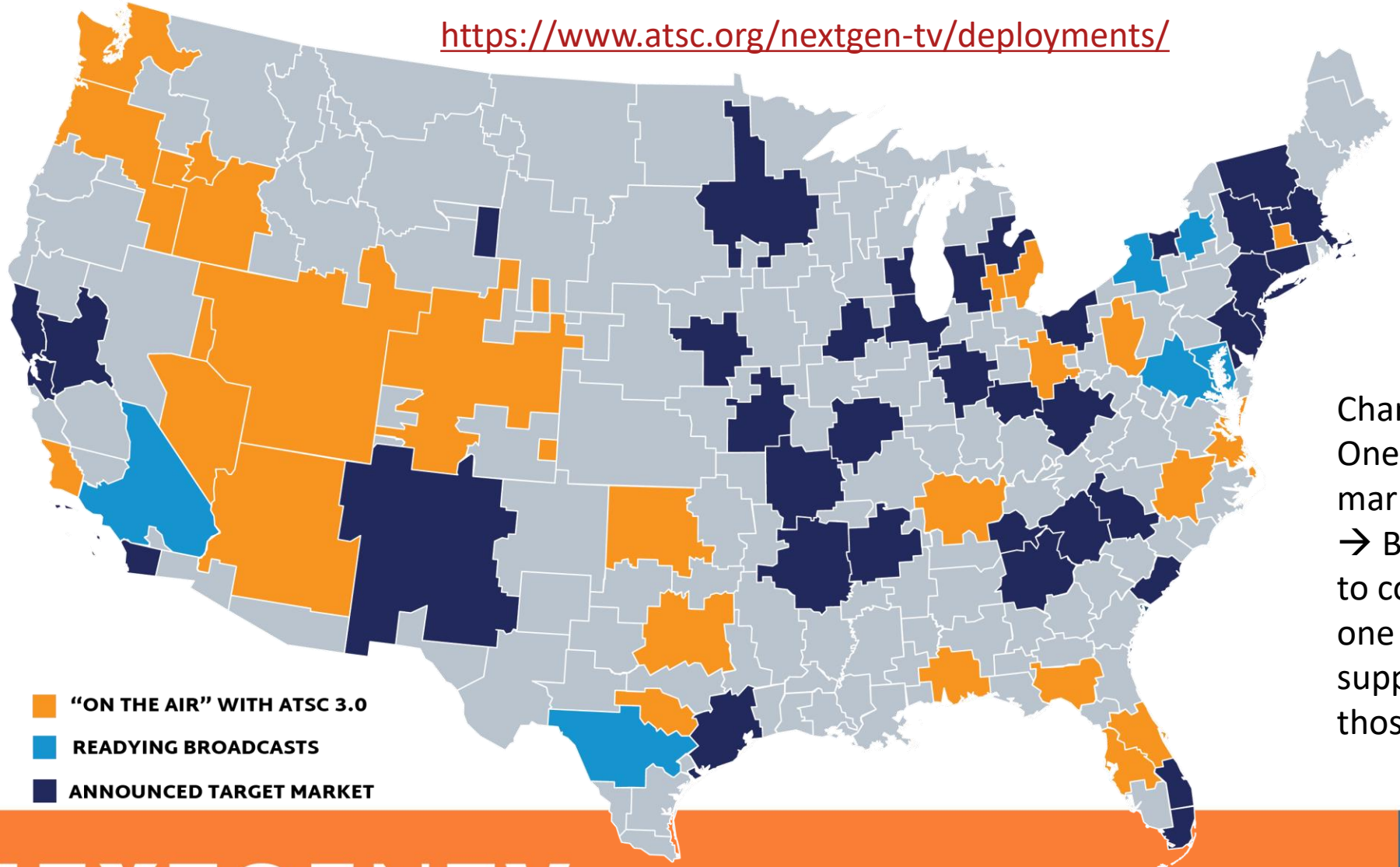
Planning Teams
- Planning Team 4 – Advanced Video Technologies
- Planning Team 5 – Automotive Applications
- Planning Team 6 – Global Recognition of ATSC 3.0

SBE ATSC 3.0 Specialist Certification
- Webinar and Seminar series
- Exam development

Revision Process
- Striking the right balance between evolution and stability

Deploying the ATSC 3.0 Broadcast System

https://www.atsc.org/nextgen-tv/deployments/



Channel sharing structure:
One host station supports many market broadcasters.
→ Broadcasters work together to combine ATSC 1.0 signals on one host, and another host supports ATSC 3.0 signals of those broadcasters.

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Questions?