Technology Series Webcast

SMPTE Enabling Global Education

SMPTE ATSC 3.0 Webinar
Part 1: Introduction

Madeleine Noland
Senior Advisor Technology & Standards, LG Electronics
Chair, ATSC Technology Group 3
madeleine.noland@lge.com

SMPTE Technology Webcast Series Sponsored by:

AJA VIDEO SYSTEMS

POWERED BY ATSC 3.0

Your Host

Joel E. Welch

Director of Education
SMPTE

SMPTE Technology Webcast Sponsors

- *Thank you to our sponsor for their generous support:*

AJA® VIDEO SYSTEMS

SMPTE Technology Webcasts

- Series of monthly 60- to 90-minute online, interactive webcasts covering a variety of technical topics
- Free professional development benefit for SMPTE members
- Sessions are recorded for member viewing convenience.

Housekeeping

- Please indicate you want to ask verbal question by indicating such in the chat box
  - If you do not have a microphone, please submit your questions via text
- SMPTE provides a PDF of select slides used during webcasts in exchange for your feedback
  - Once your feedback is submitted, you will automatically be redirected to the PDF for downloading
- Please feel free to post or blog about today's webcast on your social media platform of choice

@smpteconnect

#SMPTEWebcast

Views and opinions expressed during this SMPTE Webcast are those of the presenter(s) and do not necessarily reflect those of SMPTE or SMPTE Members.

This webcast is presented for informational purposes only. Any reference to specific companies, products or services does not represent promotion, recommendation, or endorsement by SMPTE

Today's Guest Speaker

Madeleine Noland

Senior Advisor Technology & Standards
LG Electronics
Chair, ATSC Technology Group 3

Agenda

- ATSC 3.0 Overview
- Physical Layer and Transport Layer
- Audio, Video and Captions
- Interactivity
- Advanced Emergency Alerts
- Security

NEXTGENTV POWERED BY ATSC 3.0

About the ATSC

Standards development organization for digital television

- Founded in 1983 by CEA, IEEE, NAB, NCTA, and SMPTE
- Focused on terrestrial digital television broadcasting

ATSC is an open, due process organization

- Approximately 150 member organizations
- Broadcasters, broadcast equipment vendors, cable and satellite systems, consumer electronics and semiconductor manufacturers, universities

ATSC Mission Statement:

- To create and foster implementation of voluntary Standards and Recommended Practices to advance terrestrial digital television broadcasting, and to facilitate interoperability with other media.

NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Participation

373 individuals on reflector/document system

- Many others focused on 3.0 development efforts

150 organizations

- Broadcasters
- Consumer Electronics Manufacturers
- Professional Equipment Manufacturers
- R&D Laboratories
- Universities

International Participation

- Canada
- China
- Europe (including DVB)
- Japan (including NHK)
- South Korea
- United States

NEXTGENTV POWERED BY ATSC 3.0

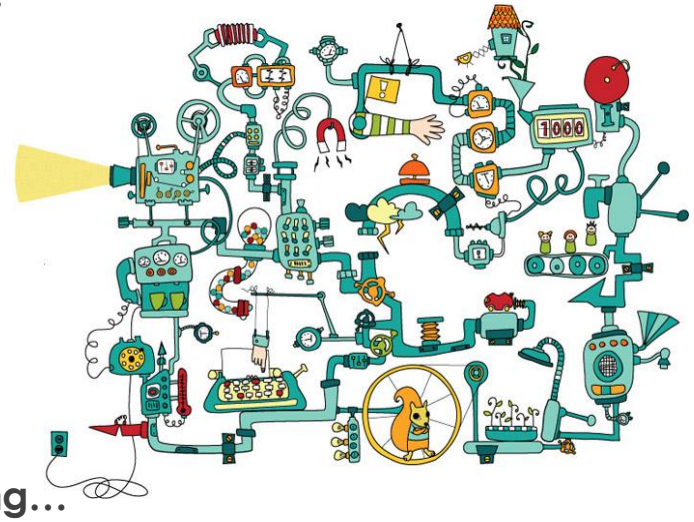
Goals of ATSC 3.0

To add value to the broadcasting service platform → Enables new business models → Reaches more viewers on more devices

To address changing consumer behavior → Provides higher quality audio and video, more accessibility → Watch what you want, when you want, where you want

NEXTGENTV POWERED BY ATSC 3.0

And so we set to work…



And came up with something…

NEXTGENTV POWERED BY ATSC 3.0

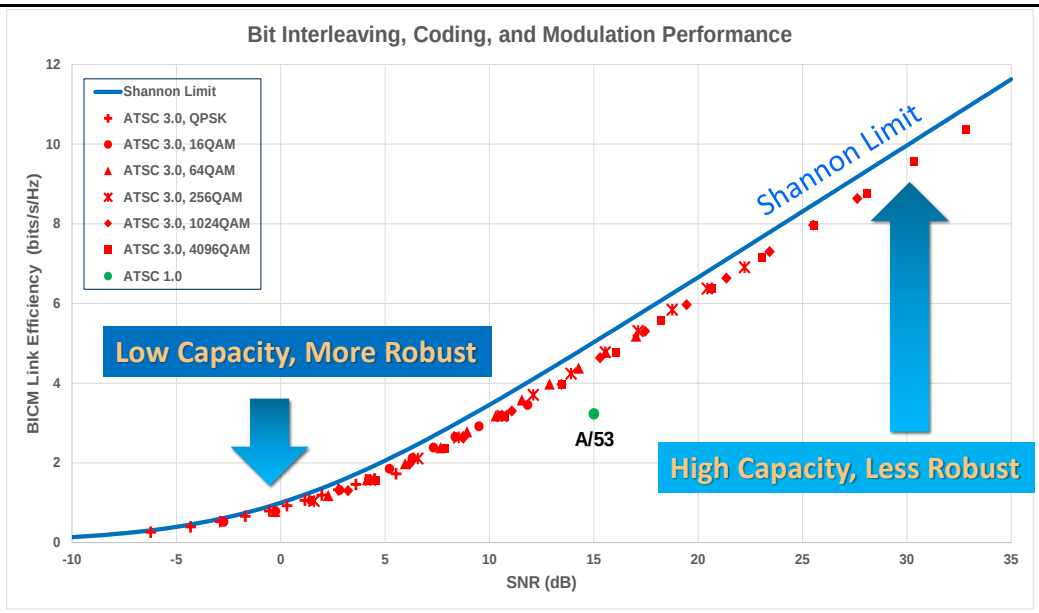
Key Advancements in 3.0

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

NEXTGENTV POWERED BY ATSC 3.0

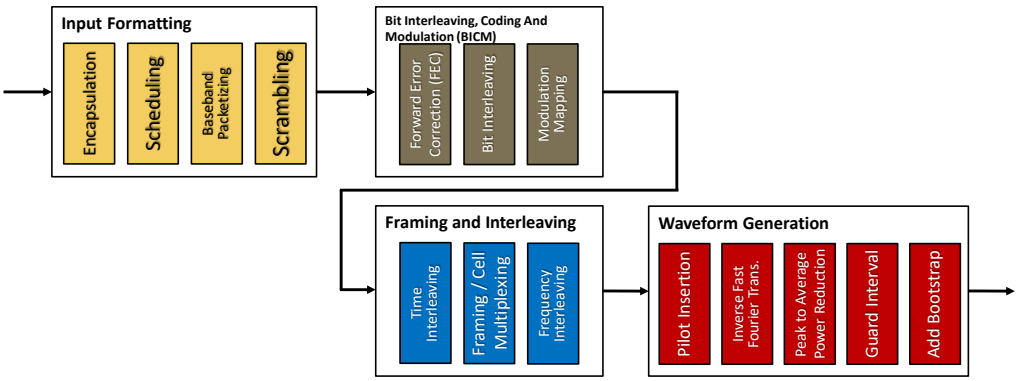
ATSC 3.0 Physical Layer and Transport Layer

NEXTGENTV POWERED BY ATSC 3.0



NEXTGENTV POWERED BY ATSC 3.0

Physical Layer Architecture



NEXTGENTV POWERED BY ATSC 3.0

Frame Hierarchy for Payload

Frames

- The largest physical layer container for carrying data traffic is a physical layer frame

Subframes

- Each frame contains one or more subframes
- Each subframe is associated with a subframe type, which is a function of the OFDM configuration parameters for that subframe
- Subframes within the same frame can have the same or different type

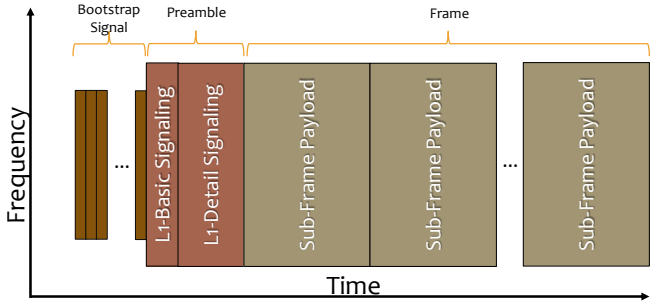
Physical Layer Pipes (PLPs)

- Each subframe contains one or more physical layer pipes which carry actual payload data
- A PLP's throughput capacity depends on: Forward Error Correction (FEC) code rate, modulation order, and number of allocated cells
- Multiple PLPs for different services can share the same subframe
- Maximum of 64 distinct PLPs in an RF channel; maximum of 4 PLPs in a given service

NEXTGENTV POWERED BY ATSC 3.0

Signaling Hierarchy

A frame consists of bootstrap, preamble, and data portions



- The bootstrap serves as the robust universal entry point to a waveform and signals parameters that enable decoding of L1-Basic
- L1-Basic signals parameters that enable the decoding of L1-Detail and the initial processing of the first subframe.

NEXTGENTV POWERED BY ATSC 3.0

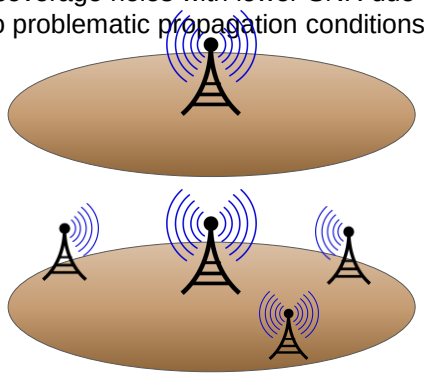
Layer Division Multiplexing (LDM)

- Layer Division Multiplexing (LDM) is based upon the superposition of two signals operating at different amplitude (power) levels.
- LDM Capable Receiver is able to "subtract" the core layer to decode the enhanced layer
- LDM provides large "gain" in transmission efficiency
- Time Division Multiplexing (TDM), Frequency Division Multiplexing (FDM) along with LDM are all possible

NEXTGENTV POWERED BY ATSC 3.0

Single Frequency Networks

Single stick antenna may result in coverage holes with lower SNR due to problematic propagation conditions

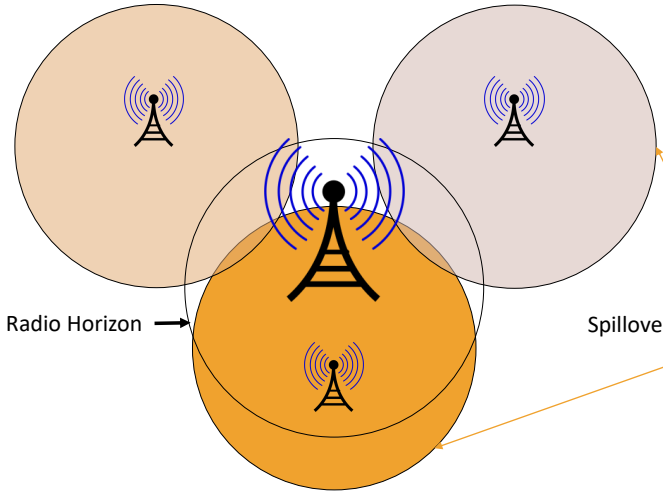


SFN with multiple transmitters increases coverage by boosting SNR in coverage holes

- Multiple transmitters in an SFN can be used to extend coverage and add capacity by raising SNR.
- OFDM (Orthogonal Frequency Division Multiplexing) guard interval alleviates potential inter-symbol interference arising from multiple transmitters.
- MISO (Multiple Inputs, Single Output) can be used to artificially decorrelate signals from multiple transmitter to avoid destructive interference.

NEXTGENTV POWERED BY ATSC 3.0

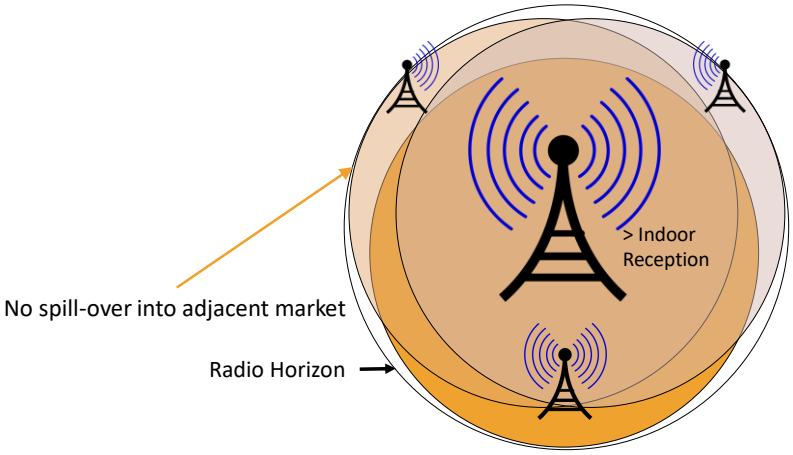
Single Frequency Network (1)



This set-up can be used to enable continuous service from one DMA to another

NEXTGENTV POWERED BY ATSC 3.0

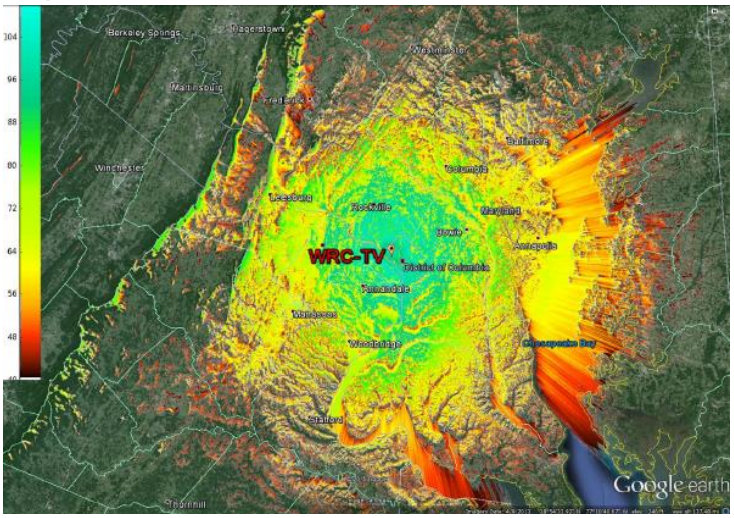
Single Frequency Network (2)



This set-up can be used to increase coverage in a given DMA

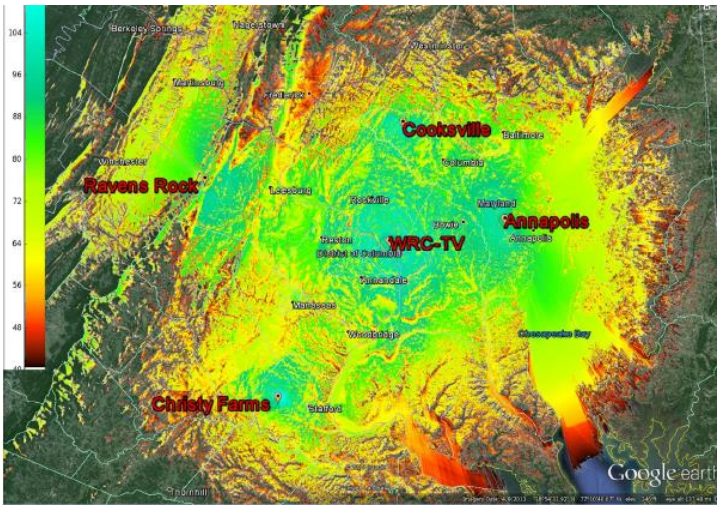
NEXTGENTV POWERED BY ATSC 3.0

Washington, DC without SFN (example)



NEXTGENTV POWERED BY ATSC 3.0

Washington, DC with SFN (example)



NEXTGENTV POWERED BY ATSC 3.0

Scenario: Deep Indoor Reception & Mobile, Single Stick

Single Station All Robust/Mobile Services

TDM; 8K FFT (Fast Fourier Transform); QPSK; 64800 LDPC (Low Density Parity Check); 148uSec Guard Interval

Two PLP's

- 1 HD+ Service ~4.34MB, Threshold AWGN 2.0dB (Rayleigh 4.4dB) 9/15 FEC; 250mSec Frame
- 5-7 Robust/Mobile Video Services ~ 0.45MB Threshold AWGN -4.3 dB (Rayleigh -3.6 dB) 3/15 FEC; 100mSec Frame

Opportunity	Opportunity Variation	Multiplex Capacity	Targeted Receivers	Service Assignments	Channel Loading (BCN On)	PLP Capacity (Mbps)	Channel Occupancy (%)	AWGN SNR (dB)	Rayleigh SNR (dB)	Doppler (MPH)
Deep Indoor Reception + Mobile Single Stick	TDM Only	6-8	Fixed & portable deep indoor receivers	1 HD Service (+ Audio)	PLP1: 8 K FFT, 148 usec GI, QPSK, 64800 LDPC, 9/15 FEC, 250 msec Frame	4.34	75	2.00	4.40	89.8
				Mobile Video & Audio & Signaling	PLP2: 8 K FFT, 148 usec GI, QPSK, 648000 LDPC, 3/15 FEC, 100 msec Frame	0.45	25	-4.30	-3.60	179.6

NEXTGENTV POWERED BY ATSC 3.0

Scenario: Multicast HD/SD Robust Core SFN

Single Station Transmits Both Fixed and Mobile Services

HD and Mobile on single ATSC 3.0 RF Channel

TDM; 16K FFT; 64QAM; 64800 LDPC; 148uSec Guard Interval;

Three PLP's

- 2 HD+ Services ~8.7MB, Threshold AWGN 14.28dB (Rayleigh 17.4dB)11/15 FEC; 250mSec Frame
- 3-5 Mobile SD Services~ 2.97MB Threshold AWGN 2.82 dB (Rayleigh 4.32 dB)5/15 FEC; 250mSec Frame
- Audio Service ~0.66MB Threshold AWGN -1.7dB (Rayleigh -0.55dB)5/15 FEC; 100mSec Frame

Opportunity	Opportunity Variation	Multiplex Capacity	Targeted Receivers	Service Assignments	Channel Loading (BCN On)	PLP Capacity (Mbps)	Channel Occupancy (%)	AWGN SNR (dB)	Rayleigh SNR (dB)	Doppler (MPH)
Multicast HD/SD Robust Core SFN Audio Services	TDM Only	5-7	Fixed	2 HD in video stat mux Pool	PLP1: 16 K FFT 148 usec GI, 64 QAM, 64800 LDPC, 1/15 FEC, 250 msec Frame	8.70	38	14.28	17.44	95.1
			+Robust Services	+3-5 SD in video stat mux pool	PLP2: 16 K FFT, 148 usec GI, 16 QAM, 648000 LDPC, 5/15 FEC, 250 msec Frame	2.97	43	2.82	4.32	95.1
				+Audio	PLP3: 16 K FFT, 148 usec GI, QPSK, 648000 LDPC, 5/15 FEC, 250 msec Frame	0.66	19	-1.70	-0.55	95.1

ATSC 3.0 Mobility

HD mobile on the autonomous shuttle (NAB-2018, Las Vegas)

NEXTGENTV POWERED BY ATSC 3.0

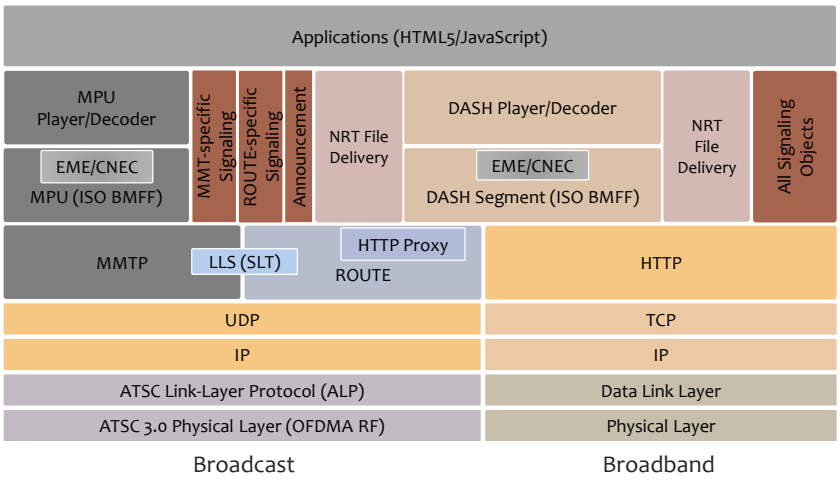
ATSC 3.0 Transport Layer

The ATSC 3.0 Management and Protocols Layer encompasses

- Service delivery and synchronization
- Service announcement and personalization
- Interactive services and companion screens
- Redistribution support / watermarks

IP Transport is used for delivery of both OTA and OTT content

The use of IP transport is a game-changer for broadcasting



NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Video System

NEXTGENTV POWERED BY ATSC 3.0

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

NEXTGENTV POWERED BY ATSC 3.0

Legacy and Progressive Video Formats

Legacy Interlace Video Formats

- SD: {640,704,720}x480
- HD: {1440,1920}x1080

Progressive Video Formats

- Resolutions: 16:9/square pixels, divisible by 8 in both dimensions, up to 3840x2160
- HDR, WCG, HFR, 4K, Scalable, etc. are only supported for progressive formats

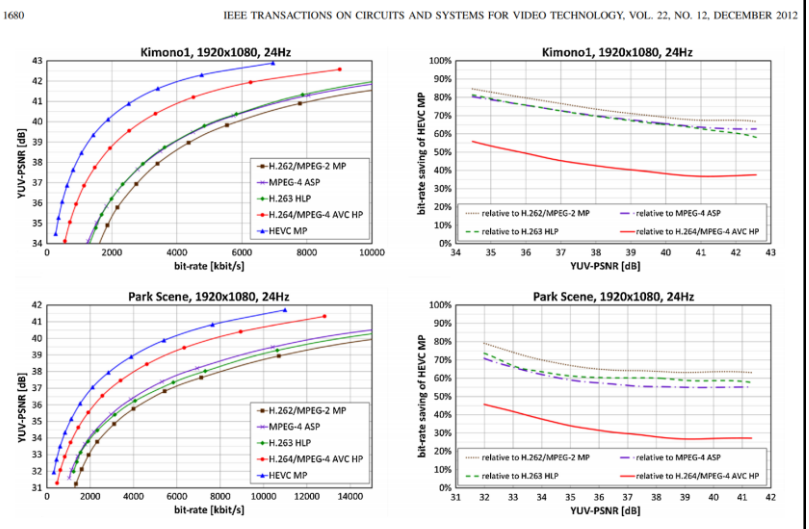
NEXTGENTV POWERED BY ATSC 3.0

HEVC

HEVC Main 10 Profile specified

35-50% performance gains vs. AVC/ H.264

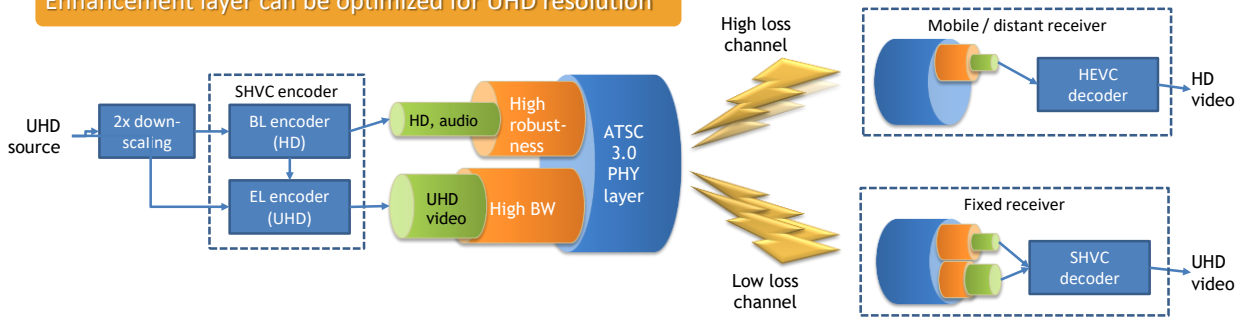
10-bit codec is required for HDR



NEXTGENTV POWERED BY ATSC 3.0

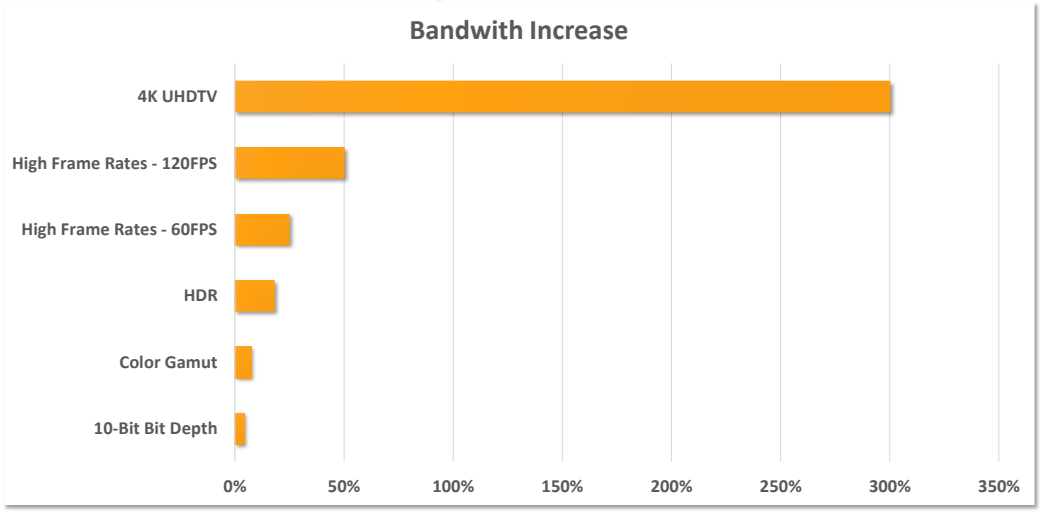
SHVC: Spatial Scalability

- Limited to 2 spatial layers
- Base layer can be optimized for mobile reception
- Enhancement layer can be optimized for UHD resolution



NEXTGENTV POWERED BY ATSC 3.0

HDR/WCG: "Good Bang For The Bit"



NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Audio System

NEXTGENTV

POWERED BY ATSC 3.0

Overview

1.) **Personalization**

2.) **Enhanced Surround Sound**

ATSC 3.0 Audio Systems

2 audio technologies are standardized in the ATSC 3.0 suite

Dolby AC-4

MPEG-H AUDIO ALLIANCE
The Next-Generation System for Interactive and Immersive Sound

1 technology per country or region

- **Dolby AC-4 for use in the U.S.**
- **MPEG-H in South Korea**

NEXTGENTV POWERED BY ATSC 3.0

Audio: Personalization

Choose language

Choose commentary

Address impairments with description and improved intelligibility

Normalize loudness of all content

Contour dynamic range to the unique user, device and environment

NEXTGENTV POWERED BY ATSC 3.0

Immersive, Enhanced Surround Sound

Improved spatial resolution in sound source localization

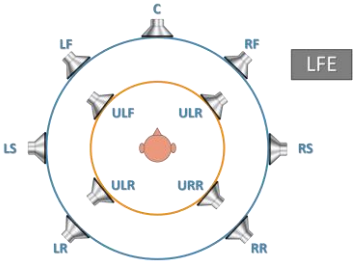
- Sound with improved azimuth, elevation and distance perspective
- Use of channels and objects or “elements” and metadata (similar to fader automation)
- Metadata allows rendering at the decoder, customized to the user’s sound system
- The decoder places the sound in the most accurate position the user’s sound system supports

NEXTGENTV POWERED BY ATSC 3.0

Rendering for Headphones

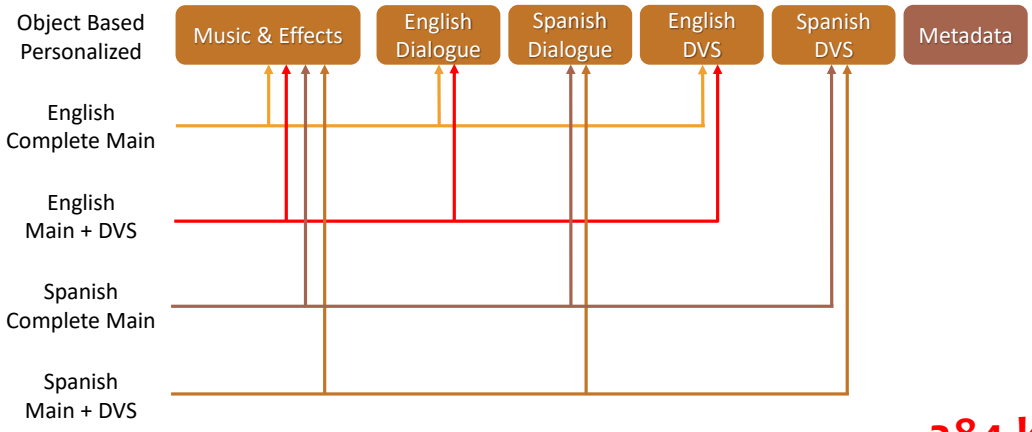
Headphone Reproduction Will Simulate Height & Depth –

Sounding more like speakers and the feeling of listening in a room



NEXTGENTV POWERED BY ATSC 3.0

Transmitting Audio



Dolby Laboratories

4 Complete Presentations at ~ 384kbps

384 kb/s!

NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Accessibility

NEXTGENTV POWERED BY ATSC 3.0

What is Accessibility in ATSC 3.0?

- Emergency Alerts & Messaging
  - Emergency Crawls & Audio Tracks
- Visually Impaired
  - Video Description
- Hearing Impaired
  - Closed Caption
  - Closed Signing
  - Dialog Intelligibility

NEXTGENTV POWERED BY ATSC 3.0

Visually Impaired

ATSC 1.0 requires VD to be sent as a secondary audio program typically mono or stereo mix down with narration.

ATSC 3.0 allows VD object element to be broadcast in audio stream and mixed in with music, dialog and effects with minimal effect on broadcast capacity while providing a better experience to audience.

Aural renderings of emergency messages can also be an object element

In both cases multiple versions are possible (e.g., alternate languages)

NEXTGENTV POWERED BY ATSC 3.0

Hearing Impaired

Caption Stream	• Mandatory
	  • IMSC1 via broadcast
	• Optional
	  • IMCS1 via broadband (e.g. alt. language)
	  • 608/708 in the video SEI

Dialog Intelligibility	• In ATSC 1.0 the mix cannot be easily modified. • In ATSC 3.0 the dialog can be maintained as a separate element.
Closed Signing	• Interactive standard enables Picture in Picture • PiP can be used for sign language that can be toggled on/off like captions

NEXTGENTV POWERED BY ATSC 3.0

What is IMSC1?

- W3C's "TTML Text and Image Profiles for Internet Media Subtitles and Captions"
- "IMSC1" – is a well defined profile specifically targeted at closed captions and subtitles.
- Supports world-wide language and symbol tables.
- Supports world-wide image glyph delivery.
- Supports FCC requirements for both 708 and IP captions.
- US FCC safe harbor for IP-delivered content.
- Supports ATSC 3.0 Hybrid delivery of broadcast and broadband.

NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Interactivity

NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Interactive Content – Key Features

- Describes the conceptual application operating environment
- 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

NEXTGENTV POWERED BY ATSC 3.0

Foundation 1: HTML5

HTML5: HyperText Mark-up Language, version 5

Current Web Standard

Simple Language: Elements (tags), Attributes, and Text

Refers to other pages and content using URLs

```
<a href="http://www.xbc.com/somepage.html">My Web Site</a>
```

Elements can be nested

```
<a href="http://www.xbc.com/somepage.html">
        <img class="someClass" source="images/myicon.png" title="A ToolTip" border="0"
        width="16px" height="16px" />
  </a>
```

HTML5 Pages are loaded into User Agents (e.g. Browsers)

Loaded pages are represented in a Document Object Model (DOM)

The DOM provides data and built-in APIs for JavaScript manipulation

NEXTGENTV POWERED BY ATSC 3.0

Foundation 1a: CSS – Cascading Style Sheets

- Separates presentation and content, including aspects such as the layout, colors, and fonts
- Removes the need to define styles on every element
- Allows HTML5 pages to be 'Skinned'
- Styles have selectors that can associate the style with elements, classes or patterns of elements
- Simple language with big power

```
a {
        color: #377049; font-weight: bold;
  }
```

NEXTGENTV POWERED BY ATSC 3.0

Foundation 2: JavaScript

High-level, dynamic, untyped, and interpreted run-time language

Standardized in the ECMAScript language specification

The Language of the Broadcaster Application

HTML5 & CSS describe data

JavaScript codifies logic that manipulates that data

```
<button id="hellobutton">Hello</button>
  <script>
    document.getElementById( 'hellobutton' ).onclick = function() {
      alert('Hello world!');                  // Show a dialog
      var myTextNode = document.createTextNode('Some new words.');
      document.body.appendChild(myTextNode);    // Append "Some new words" to the page
    };
  </script>
```

NEXTGENTV POWERED BY ATSC 3.0

Interactivity – Example

When a goal is scored, an event can be sent to the app causing celebration graphics to appear.

NEXTGENTV POWERED BY ATSC 3.0

Interactivity – Example

Use content splicing to personalize the experience.

NEXTGENTV POWERED BY ATSC 3.0

Interactivity – Example

Use PiP to allow viewers to follow the off-camera action or for Closed Signing or other applications

NEXTGENTV POWERED BY ATSC 3.0

ADVANCED EMERGENCY ALERTS

NEXTGENTV POWERED BY ATSC 3.0

"And imagine a world in which our emergency alert system was far more advanced, tailoring alerts to particular neighborhoods and waking up sleeping devices to warn consumers of imminent emergencies."

-FCC Chariman Ajit Pai before unanimous vote to approve Next Gen NPRM, 2/23/17

AWARN
Advanced Warning and Response Network

NEXTGENTV POWERED BY ATSC 3.0

What is Advanced Emergency Alerting?

Enables broadcasters to deliver a rich set of data and media to viewers or non-public audiences

- Text, images, video, interactive interfaces
- Viewer can dismiss messages (unlike "burned-in" crawls)

Supplements, enhances, but doesn't replace EAS

Possibility of geo-targeting

- For receivers that "know where they are"

Possibility of waking up devices in stand-by mode

Possibility of targeting (and encrypting) messaging for groups (first responders, gov't, business…)

NEXTGENTV POWERED BY ATSC 3.0

AEA Wake-up Function

The Bootstrap is the initial discovery and entry point in the ATSC 3.0 waveform

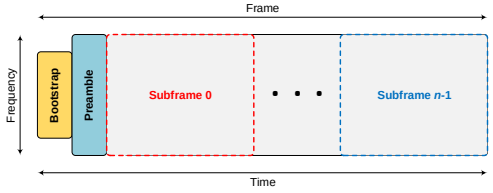
Wake-up Field is comprised of two bits in the Bootstrap

Two bits = 4 wakeup states…one negative and 3 positive

- Change in state is what matters
- Designed to avoid nuisance factor and extend battery life

Note that there is one Bootstrap per RF band

- Broadcasters that are channel-sharing must coordinate use of the wake-up bits



Value	Meaning
'00'	No emergency to wake up devices is currently signaled
'01'	Emergency to wake up devices - setting 1
'10'	Emergency to wake up devices - setting 2
'11'	Emergency to wake up devices - setting 3

NEXTGENTV POWERED BY ATSC 3.0

Advanced Emergency Alert Table

- AEAT contains the elements and attributes of the emergency messages

Who gets it

When

Alert Summary

Where

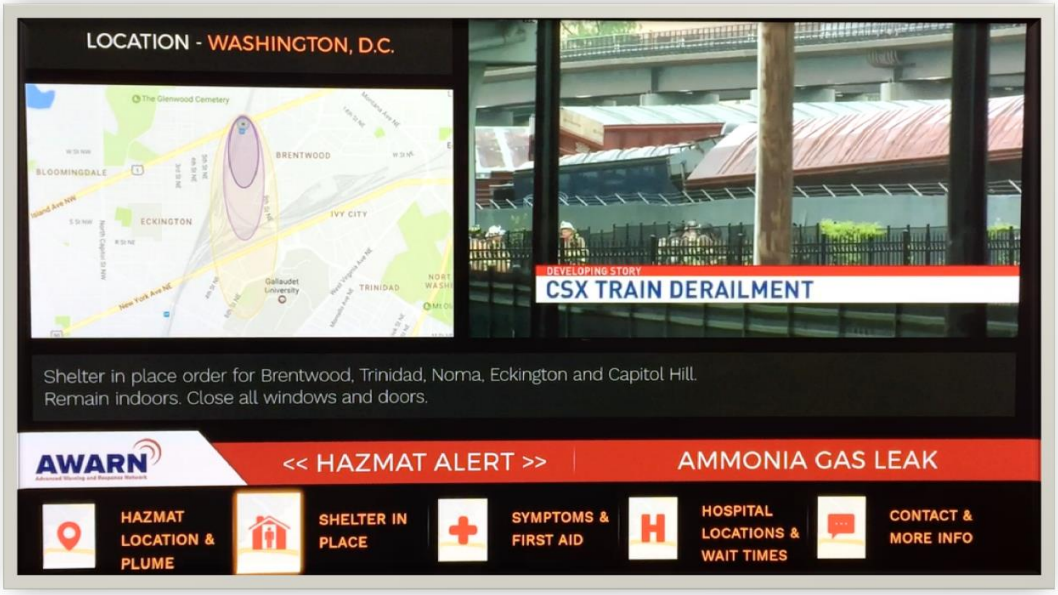
Alert Narrative

Live Media

File-based Media

Element or Attribute Name	Use	Data Type	Short Description
AEAT			Root element of the AEAT
AEA	1..N		Advanced Emergency Alert formatted as AEA-MF.
@AEAid	1	string	The identifier of AEA message.
@issuer	1	string	The identifier of the broadcast station originating or forwarding the message.
@audience	0..1	string	The intended distribution of the AEA message.
@AEAtype	0..1	string	The category of the message.
@refAEAid	0..1	string	The referenced identifier of AEA message. It shall appear when the @AEAtype is "update" or "cancel".
@priority	1	unsignedByte	The priority of the message
Header	1		The container for the basic alert envelope.
@effective	1	dateTime	The effective time of the alert message.
@expires	1	dateTime	The expiration time of the alert message.
EventCode	1	string	A code identifying the event type of the AEA message.
@type	0..1	string	A national-assigned string designating the domain of the code (e.g. SAME in US, …)
EventDesc	0..N	string	The short plain text description of the emergency event (e.g. "Tornado Warning" or "Tsunami Warning".
@lang	1	string	The code denoting the language of the respective element of the EventDesc
Location	1..N	string	The geographic code delineating the affected area of the alert message
@type	1	string	A national-assigned string designating the domain of the code (e.g. FIPS in US or "SGC" in Canada…)
AEAtext	1..N	string	Contains the specific text of the emergency notification
@lang	1	language	The code denoting the language of the respective element of the alert text
LiveMedia	0..1		
@bsid	1	unsignedShort	Identifier of the Broadcast Stream contains the emergency-related live A/V service.
@serviceId	1	unsignedShort	Integer number that identifies the emergency-related A/V Service.
ServiceName	0..N	string	A user-friendly name for the service where the LiveMedia is available
@lang	1	string	The language of the text described in the ServiceName element
Media	0..N		Contains the component parts of the multimedia resource.
@lang	0..1	language	The code denoting the language of the respective element Media
@mediaDesc	0..1	string	Text describing the type and content of the media file
@url	1	anyURI	The identifier of the media file
@contentType	0..1	string	MIME-Type of media content referenced by Media@url
@contentLength	0..1	unsignedLong	Size in bytes of media content referenced by Media@url

NEXTGENTV POWERED BY ATSC 3.0



NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 Security Features

Studio-to-Transmitter Link
- Secure path to the transmitter

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

Content Encryption
- Protects content
- Enables new business models such as:
  - Subscription services
  - "Freemium" services (i.e., content is free, but viewers must register)
  - Pay-per-view
- Based on CENC

NEXTGENTV POWERED BY ATSC 3.0

Suite of Standards

- A/300:2017, "ATSC 3.0 System"
- A/321:2016, "System Discovery and Signaling"
- A/322:2017, "Physical Layer Protocol"
- A/324:2018, "Scheduler / Studio to Transmitter Link"
- A/330:2016, "Link-Layer Protocol"
- A/331:2017, "Signaling, Delivery, Synchronization, and Error Protection"
- A/332:2017, "Service Announcement"
- A/333:2017, "Service Usage Reporting"
- A/334:2016, "Audio Watermark Emission"
- A/335:2016 "Video Watermark Emission"
- A/336:2018, "Content Recovery in Redistribution Scenarios"
- A/337:2018, "Application Signaling"
- A/338:2017, "Companion Device"
- A/341:2018, "Video – HEVC"
- A/342 Parts 1-3:2017, "Audio"
- A/343:2017, "Captions and Subtitles"
- A/344:2017, "ATSC 3.0 Interactive Content"
- A/360:2018, "ATSC 3.0 Security and Service Protection"

NEXTGENTV POWERED BY ATSC 3.0

ATSC 3.0 is a Powerful New Tool

- New business opportunities
- Flexible physical layer supports wide range of service types
- Great improvements in pictures and sound
- New interactivity features
- Advanced emergency messaging tools
- New accessibility enhancements
- More robust signal and higher data capacity
- And, and, and….

NEXTGENTV POWERED BY ATSC 3.0

Thank you. Questions?

NEXTGENTV POWERED BY ATSC 3.0

Q&A Period

Madeleine Noland

Senior Advisor Technology & Standards
LG Electronics
Chair, ATSC Technology Group 3
madeleine.noland@lge.com