ATSC 3.0
An Overview

SMPTE NEW ENGLAND SECTION       MARCH 17, 2021
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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

Powered by ATSC 3.0
ATSC 3.0 Document Structure

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

- RF Transmission
- Scheduler/ALP
- IP Delivery
- Essence (Audio, Video, Captions)
- Emergency Alerting
- Watermarks
- Interactivity
- Personalization
- Companion Devices
- PHY Return Channel
- Service Usage
- Security

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

- **Software**
  - Applications
  - Signaling
- **Pictures & Sound**
  - Data Organized as Streams and Files
  - Video
  - Audio
  - CC
  - EPG
  - Signaling
- **Transmission**
  - (Physical Layer)
  - Sound & Data Organized as Streams and Files
  - OFDM
  - Physical Layer Pipes
  - Layer Division Multiplex
  - Protocol Signaling
  - Channel Acquisition
  - EAS Wake-Up
  - Modulation Signaling
- **Finding the Signal**
  - System Discovery
  - Signaling

**Applications**
- Smart TV “Apps”
- Screen is a web page

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

**Sending Bits over the air**
- UHD
- HD & SD multicast
- Immersive Audio

**System Discovery**
- Channel Acquisition
- EAS Wake-Up
- Modulation Signaling

Software
- Smart TV “Apps”
- Screen is a web page

Pictures & Sound
- Data Organized as Streams and Files
- Video
- Audio
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Transmission
- (Physical Layer)
- Sound & Data Organized as Streams and Files
- OFDM
- Physical Layer Pipes
- Layer Division Multiplex
- Protocol Signaling
- Channel Acquisition
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- Modulation Signaling

Finding the Signal
- System Discovery
- Signaling

**NEXTGEN TV**

**POWERED BY ATSC 3.0**
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

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

ATSC 3.0

- More bit rates – 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

- **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**
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PLP0 (Mobile)</th>
<th>PLP1 (Stationary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Center Frequency</td>
<td>599</td>
<td></td>
</tr>
<tr>
<td>Subframe</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>FFT Size</td>
<td>8K</td>
<td>16K</td>
</tr>
<tr>
<td>Pilot Pattern</td>
<td>6_4</td>
<td>12_4</td>
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<tr>
<td>Pilot boost</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Guard Interval</td>
<td>G5_1024 (148us)</td>
<td></td>
</tr>
<tr>
<td>Preamble Mode</td>
<td>(Basic: 3, Detail: 3) Pattern Dx = 3</td>
<td></td>
</tr>
<tr>
<td>Frame Length</td>
<td>155 msec</td>
<td></td>
</tr>
<tr>
<td># of Symbols</td>
<td>41</td>
<td>39</td>
</tr>
<tr>
<td>Frequency Interleaver</td>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>Time Interleaver</td>
<td>Hybrid 16 FEC Blocks 1 TI Block (51.1msec time spread)</td>
<td>Hybrid 63 FEC Blocks 2 TI Block (47.8msec time spread)</td>
</tr>
<tr>
<td>Modulation</td>
<td>16 QAM</td>
<td>256 QAM</td>
</tr>
<tr>
<td>Code Rate</td>
<td>7/15</td>
<td>10/15</td>
</tr>
<tr>
<td>Code Length</td>
<td>64K</td>
<td></td>
</tr>
<tr>
<td>Contents</td>
<td>KFPH-CD (UnMas) test program</td>
<td>KTVW-DT(Univision), KPNX (NBC), KPHO (CBS)</td>
</tr>
<tr>
<td>Bit Rate (Mbps)</td>
<td>3.093</td>
<td>18.166</td>
</tr>
<tr>
<td>Required C/N (dB)</td>
<td>5.2</td>
<td>17.1</td>
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<tr>
<td>(Single diversity, AWGN)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ATSC 3.0 Mobility

Showcase for ATSC3.0 UHD Mobile During PyeongChang 2018 Winter Games

Demonstration Shuttle Bus

Bus Route for UHD Mobile Showcase

Phoenix

Santa Barbara

Mobile PLP

Mobile PLP

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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;
- 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.
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

- **Bootstrap**
- **Preamble**
- **SubFrame Boundary**
- **Data**

**Evolutionary Frame**

- **Pointer to next 'like' PHY Frame**

A/322 Table 7.2

Time (msec)

Data cells/symbol

- 100
- 200
- 300
- 400
- 500

Evolutionary Frame

*POWERED BY ATSC 3.0*
Protocols

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

![Diagram of ATSC 3.0 physical layer and protocols]

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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)

* PLP: Physical Layer Pipe
* LMT: Link Mapping Table
* LLS: Low Level Signaling
* SLT: Service List Table
* SLS: Service Layer Signaling

Link Layer Signaling

Physical Layer Frame

Sequence of MPU

* PID: packet_id in MMTP packet header

MMTP #N

Logical Link Layer Packet

Physical Layer Packet

Physical Layer Signal
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)**
  - 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 Frame Rate**
  - PQ & HLG transfer functions (plus SDR)
  - Metadata for PQ
- **High Dynamic Range**
  - Wide Color Gamut BT.2100 (plus BT.709 for SDR)
  - Y’C_bC_r non-constant luminance
  - I_C_I_C_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**

**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

**Internet Experience**
- Personalized & Dynamic
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

The system is based on standard web technologies. It works in a browser.
New business opportunity via interactive shopping
ATSC 3.0 Station Architecture with AEA

**Alert Sources**
- FEMA IPAWS
- National Weather Service
- State Agencies
- County & Local Agencies

**Authorities**

**TV Station**

**External Rich Media**

**Station Rich Media**
- Video Clips
- Graphics
- Library files

**CAP EAS Unit Content Mgmt Server**
- AEA app generator
- AEA message generator

**AEAP EAS & Messaging Platform**

**ATSC 3.0 Signaling & Scheduling**

**ATSC 3.0 Transmission System**

**Alert Sources**
- FEMA IPAWS
- National Weather Service
- State Agencies
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**External Rich Media**

**Station Rich Media**
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**AEAP EAS & Messaging Platform**

**ATSC 3.0 Signaling & Scheduling**

**ATSC 3.0 Transmission System**

**TV Station**

**Powered by ATSC 3.0**
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
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

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.
Questions?