Rich Chernock
ATSC TG3 Chair
Triveni Digital CSO
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 120 member organizations
  – Broadcasters, broadcast equipment vendors, cable and satellite systems, consumer electronics and semiconductor manufacturers, universities
SCOPE OF ATSC 3.0
WHY NOW?
Broadcast Industry Model

• The traditional broadcast paradigm is based upon use of a common open standard
  – Industry standard is set and approved by the FCC
    • Broadcast equipment manufacturers build equipment compliant with the standard
    • Broadcasters transmit signals that are compliant with the standard
    • CE manufacturers build equipment that is compliant with the standard
  – Consumer TVs receive all broadcast stations
NTSC Broadcast System

- Very successful technical standard
  - More than 50 year lifetime
- Single 6 MHz RF channel
  - Channel # = brand
  - Single “program”
    - One video stream – first monochrome, then compatible color
    - One audio stream – first mono, then stereo, and later SAP added
  - Closed captioning
Perspective on ATSC 1.0

- ATSC 1.0, A/53, provided
  - High-definition video
  - Multicasting capabilities
  - 5.1 digital surround sound
  - Electronic program guides
  - Enhanced closed captioning
  - Mobile digital TV (added in 2009)

- Grand Alliance system was a revolution in 1993
Today: Rapid Advances, Ongoing Disruptions
Competitive Landscape

- Cable modems offer up to 100 Mbps to consumers
- WiFi 802.11ac operates at 1300 Mbps
  - 1999: 802.11b, 11 Mbps
  - 2009: 802.11n, 600 Mbps
  - 2013: 802.11ac, 1300 Mbps
- 4G networks capable of 12 Mbps
- HDTV, digital smart TVs, LED / LCD displays common
- 4K Ultra-HD available, programming provided by
  - Netflix, Blu-ray Disc, Amazon Prime, others
Motivations for ATSC 3.0

- Business – Need new revenue opportunities, especially to exploit mobile services
- Technology – Opportunity to design and enable a new platform
- Regulation – Need to solve spectrum crunch
- CE industry – Looking for new market opportunities
  - Business partners are key to developing new markets
Requirements for a New System

• Flexible, robust transmission system
  – Greater capacity (more bits per channel)
  – Ability to trade-off capacity for robustness
  – Integrated mobile capabilities

• Advanced audio/video coding systems
  – Ultra-high-definition video
  – Immersive and personalized audio

• Future capabilities
  – Extensible and scalable
ATSC 3.0 ATTRIBUTES AND BENEFITS
What is the Goal of ATSC 3.0?

• To improve the television viewing experience
• To add value to broadcasting’s service platform
  – Extending reach, adding possible new business models
  – Providing higher audio and video quality, more accessibility
  – Personalization and interactivity
• To address changing consumer behavior and preferences
  – TV content on all devices, both fixed and mobile
• …All without the restriction of backward compatibility
The Next Revolution in Broadcasting

• How is an advance possible?
  – Advances in video compression: MPEG-2 … MPEG-4/AVC … MPEG HEVC
  – Advances in audio compression: Dolby Digital … AAC … object-based audio
  – Advances in digital transmission and error-correcting codes
• Tapping these new advances permits a complete new system, however…
  – Because it is not backwards-compatible, the system must offer significant performance improvements and new services
Benefits for Consumers

• Maintain competitive top-tier picture and sound quality
• Reach new consumer devices with broadcast platforms
• Leverage the power of broadcasting and the internet
• More flexible and efficient use of the spectrum
• Potential for a world standard
Extensibility/Evolution

- ATSC 3.0 meant to last, but technology advances rapidly
- Methods to gracefully evolve must be in the core
  - Signal when a layer or components of a layer evolve
  - Signal minor version changes and updates
  - Signal major version changes and updates
- Goal is to avoid disruptive technology transitions
  - Enable graceful transitions
The Elevator Pitch

- Next generation broadcast television
  - Significantly higher data capacity
  - Flexible spectrum use
  - Higher physical layer robustness
  - Future extensibility
  - Mobile handheld support
  - Hybrid broadcast + broadband delivery
  - Advanced A/V compression
    - Immersive audio
    - UHD support

ATSC 3.0
- Configurable
- Scalable
- Efficient
- Interoperable
- Adaptable
THE ATSC 3.0 STANDARD
Basic ATSC 3.0 Use Cases

• Flexible use of spectrum
• Robustness
• Mobile services
• Ultra-HD
• Hybrid services
• Multi-view/multi-screen
• 3D content (video)
• Enhanced and immersive audio

• Advanced accessibility
• Advanced emergency alerting
• Personalization / interactivity
• Advanced advertising / monetization
• Common world standard
System Layers and TG3 Specialist Groups

- TG3/S31, System Requirements and Program Management
- TG3/S32
- TG3/S33
- TG3/S34
- TG3/S36

**Physical**
- Sending bits over the RF channel

**Management/Protocols**
- Organizing bits into files, streams, and packets

**Applications/Presentation**
- Software, pictures, and sound

**Security**
- Service/content protection

TG3/S31, System Requirements and Program Management

Diagram:
- Physical
- Management/Protocols
- Applications/Presentation
- Security

Legend:
- Service/content protection
- Software, pictures, and sound
- Organizing bits into files, streams, and packets
- Sending bits over the RF channel
PHY/Overview

- The ATSC 3.0 physical layer encompasses
  - Common system elements
  - Modulation and coding
  - Waveforms
  - Core broadcast services

- TG3/S32
PHY/Needs of Broadcasters

- **Flexibility**
  - Different service offerings
  - Different service areas and terrain

- **Robustness**
  - Different transmission and reception environments
  - Mobile and pedestrian operation

- **Efficiency**
  - A physical layer that can evolve over time
PHY/Re-Thinking the Physical Layer

• ATSC 1.0 broadcasters have operated with a single constrained physical layer throughput of 19.39 Mbps since 1995

• ATSC 3.0 needs flexibility in operating points
  – Huge number of possible operating points very close to the Shannon limit
    • Low capacity, highly robust
    • High capacity, less robust
PHY/Comparison

- ATSC 1.0 physical layer
  - One bit rate – 19.39 Mbps
  - One coverage area – 15 db CNR (rooftop)
  - Service flexibility – HDTV, multicast, data

- ATSC 3.0 physical layer
  - More bits/Hz – near theoretical limit
  - Flexible bit rate and coverage area choices
  - Enable on-channel repeaters for robust indoor and mobile reception
  - Multiple simultaneous “pipes”

8-VSB with fixed (188,210) RS FEC
ATSC 1.0 Physical Layer - REVIEW

ATSC 1.0 broadcasters have operated with a SINGLE constrained PHY throughput of 19.39 Mbps since 1997

ATSC 3.0 needs flexibility in operating points

One operating point
Physical Layer Skeleton Architecture

Skeleton architecture is being filled with details.
• OFDM Based Waveform
• LDPC based FEC
• Extensibility
  – “Bootstrap” – System selection signaling
    • Extremely robust
    • Essentially unchanged in the future
    • Allows evolving the Phy system over time
  – Preamble – System parameters
  – Payload
• Baseline feature recommendations
  – FEC codes, Constellations, Bit Interleaver
  – Modulation, Multiplexing, Waveform Parameters
  – Pilots
  – More…
Capacity Curve in AWGN at BER=1E-6

- **64k QPSK**
- **64k 16QAM**
- **64k 64QAM**
- **64k 256QAM**
- **64k 1024QAM**

**Shannon Limit**

**Low Capacity, Robust**

**High Capacity, Less Robust**
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.
• The ATSC 3.0 management and protocols layer encompasses
  – Service delivery and synchronization
  – Service announcement and personalization
  – Support for Interactive services and companion screens
  – Redistribution support/ACR

• TG3/S33
Common elements include
- Use of IP transport
- Use of ISOBMFF as a content format for “streaming” delivery
- Use of UTC (or some other form of "absolute" time) for synchronization and buffer management
- Use of both Broadcast and Broadband for service component delivery
Management/ESG

• Service Guide based on OMA Bcast 1.0.1
  – Some aspects of OMA Bcast 1.1
  – Extensions for ATSC 3.0
  – Somewhat similar to ESG for A/153 (ATSC Mobile DTV)

• Personalization
  – Framework to allow personalization of
    • Content
    • Advertising

• Content Advisory
  – Supporting US content advisory system in ATSC 3.0 environment

• Service Usage and Reporting
  – Enable broadcasters ability to gather
    • Information about services consumed
    • Information about service components consumed
MGT/Redistribution Support

- Programs delivered to a TV via multichannel video program distributors (MVPDs) typically do not contain all components of the original terrestrial broadcast
  - Certain ATSC 3.0 functionality designed to be discovered and interpreted by the TV, e.g. interactive applications associated with the main program, could be lost
  - Automatic Content Recognition (ACR) mechanism associated with a media component can be used to identify the content, content source, and current time of viewing, to in turn enable the TV to access the desired additional functionality via the Internet
- A Call for Proposal on a Watermarking (WM) based solution was issued YE ‘13
  - Ongoing evaluation of five Audio-based and three Video-based WM solutions
- Fingerprinting based on ATSC 2.0
Management/Other

• Companion Device communication protocol
  – Communications between Primary device (typically TV) and Companion device (tablet, smartphone)
  – Allows interactivity to move off of big screen or be personalized

• Interactivity Signaling
  – Communications to enable / trigger interactivity
  – Broadcaster driven

• Return path protocol
  – Based on update to A/96
The ATSC 3.0 applications and presentations layer encompasses

- Video coding
- Audio coding
- Presentation logic and service frameworks
- Runtime environment

TG3/S34
APP/Consumer Experiences

- The application and presentation layer is focused on what the consumer experiences
  - Service models and types
  - Multiple device support
  - Video, audio, and closed captions
  - Interactivity, personalization, alternative component selection, etc.
    - HTML5/internet overlay graphics
    - Hybrid, merged broadcast, and internet delivery
    - Personalization, interactivity, and synchronized second-screen
Flexible Service Model - Services

- Enhanced linear TV, plus on-demand support
- Subscription and PPV support
- Conditional access and DRM capabilities
- Mobile and fixed device plus companion device support
- Hybrid delivery (broadcast and broadband)
- Automatic content recognition (ACR)
- Flexibility for future business opportunities
Flexible Service Model - Components

– Flexible component delivery mechanisms
  • Different delivery methods (broadcast, broadband)
  • Different levels of robustness (high robustness vs. high bitrate)
  • Different delivery times (NRT, real-time continuous stream)

– Components dynamically combined at receiver
  • Select components automatically (e.g., low/high bit rate versions)
  • User selects components (e.g., alternative camera angle component)
  • Media time signaling enables tight synchronization at the receiver
APP/Video/Overview

- Enhanced HD and UHD
- Hybrid broadcast/broadband delivery support
- High efficiency compression
- Multiple, selectable video components
- Alternate camera angles
  - Multi-view (e.g., picture-in-picture)
  - Multi-screen and companion device support
- The ATSC 3.0 video system will take advantage of recent advances in coding technologies
- General agreement on
  - Progressive only for UHD resolution
  - Codec based on HEVC
- Scalable video coding is being carefully studied
APP/Video/Enhancements

- Video system enhancements include
  - 1080p formats
  - High Dynamic Range
  - Higher frame rate anticipated
  - Wide color gamut
- Additional HD resolutions are being considered, e.g., 2560 x 1440
- HD delivery to mobile devices
APP/Video/More Pixels, Better Pixels

• Video with ATSC 1.0
  – Common data rates for HDTV using MPEG-2 = 12–18 Mbps; SDTV = 3–5 Mbps; dynamic range = 100-nit, color gamut = Rec. 709, 8 bits/pixel

• Video with ATSC 3.0 (work in progress)
  – 4K now
    • Possibly 8K in the future
  – **High dynamic range** (1000-nit)
  – **Wide color gamut** (Rec. 2020)
  – **High Frame Rate**
  – 10 bits/pixel
  – Estimated data rates using HEVC
    • 4k = 18–30 Mbps, HD = 3–8 Mbps, SD = 1–2 Mbps
New personalization features
Enhanced immersive experience
Targeted to various devices (fixed, mobile) and speaker set-ups
  - Support for audio-only content as well as A/V content
  - Hybrid broadcast/broadband delivery support
  - Normalization of content loudness and contouring of dynamic range, based on the specific capabilities of a user’s fixed or mobile device and unique sound environment
High efficiency compression
APP/Audio/Personalization

- Selectable, mixable audio components
- Control of dialog
  - Hearing-impaired can raise dialog level
- Alternate audio tracks
  - Alternate language tracks
  - Special commentary, and music and effects
- Normalization of loudness, contouring dynamic range
  - Based on capabilities of the device and sound environment
APP/Audio/Object Audio

- Use of objects or “elements” and steering metadata
  - Metadata allows rendering at the decoder, customized to the user’s sound system
  - The decoder/renderer places the sound in the most accurate position the user’s device or sound system supports
  - Multiple receiver types are supported
    - Fixed, large screen
    - Tablets and other portable devices
    - Loudspeakers and headphones
Audio Interactivity

- Select commentary
- Mute commentary
- Control commentary volume independently
- Position commentary in 3D space.
- Change overall sound field according to POV
APP/Audio/Immersive

• High spatial resolution in sound source localization in azimuth, elevation, and distance
  – Increased sense of the sound envelopment, and enhanced “suspension of disbelief”
• Targeted to various devices (fixed, mobile)
• Targeted to various speaker set-ups and headphones
  – Including sub-optimal set-ups
• Support for audio-only content as well as audio/video content
A Call for Proposals was issued in December 2013
  - Three response received
    • Dolby
    • DTS
    • MPEG-H Alliance (Fraunhofer, Technicolor, Qualcomm)
  - Test content has been assembled
  - Testing will begin later this year
  - Proponents are proceeding according to the detailed schedule given in the CfP
Security

• Addressing topics such as:
  – How to support Subscription & PPV?
  – Technology choices/ecosystems for CA, DRM, etc
  – Security for Broadband Communications (eg. SSL/TLS)
  – 2-way trust between primary and second screens
  – Certificate revocation mechanisms
  – Signing mechanisms for interactive applications
  – And more…

• S36
PROGRESS AND SCHEDULE
The Path to ATSC 3.0

- Planning (2010-2011)
- Requirements (2011-2013)
- Development (2012-2015)
- Standards, Products (2016→...)

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Overall Schedule


System Requirements

CFP Proposals Evaluate Select

Working Draft

Candidate Standard

Proposed Standard

Standard

Industry

Technology Demos

Testing

Product Design

Commercial Launch
Transition Challenges

- The spectrum challenge – no additional spectrum for a second service
  - Stations within a DMA could channel-share to create a dual service during transition
- The receiver challenge – new devices needed for consumers
  - Possible “stick tuner” (dongle, thumb drive, etc.) for current flat panel TV’s, and/or set-top converters
  - Industry-driven campaign to include tuner in portable devices (tablets, lap tops, smart phones, etc.)
  - Adoption by other countries will foster product development
Critical Next Steps

• Complete the standard
  – Develop practical transition scenarios
  – Update current business plans, and develop new business strategies
  – Gain regulatory approval for use of ATSC 3.0

• Commercial launch, which includes
  – Broadcast hardware build-out
  – Cooperative new product development with the CE industry
  – Sell the product to consumers

• Industry collaboration is essential
In Summary

- Will not be backward compatible to the legacy system
- Acknowledges changes of user environments and needs
- Understands broadcast spectrum regulation issues
- Supports viability and new business models of broadcasters
- Flexible to accommodate future improvements and developments
rchernock@trivenidigital.com

THANKS. QUESTIONS?