Advancements in Terrestrial Broadcasting

ATSC 3.0 – Next Gen Broadcast System

Humber College

Madeleine Noland, President ATSC
mnoland@atsc.org

Standards Development Organizations

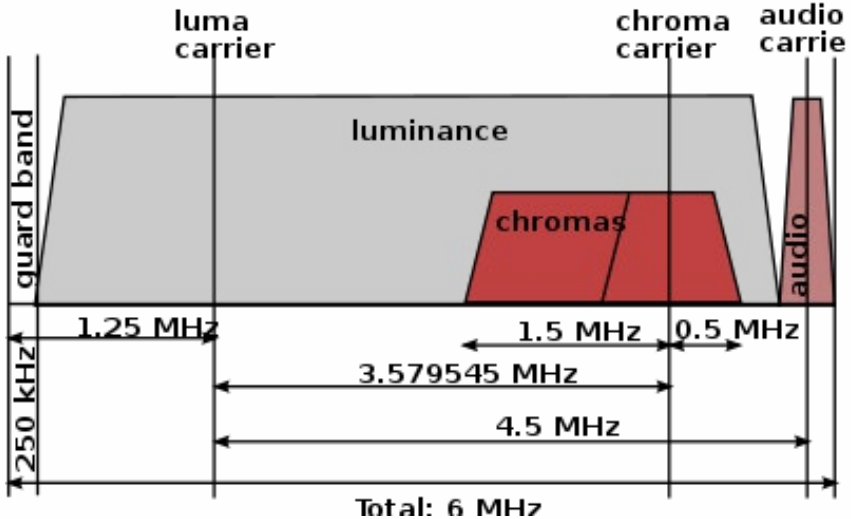
- SDOs create technical documentation enabling industries to move forward quickly by reducing fragmentation.
- Standards allow companies to produce products that can be reasonably expected to interoperate with other products.
- For terrestrial broadcasting, broadcast airwaves and content must interoperate with receivers, e.g., TVs radios, etc.

Example of simple standards-based solution

Example of mixed standards/proprietary solution

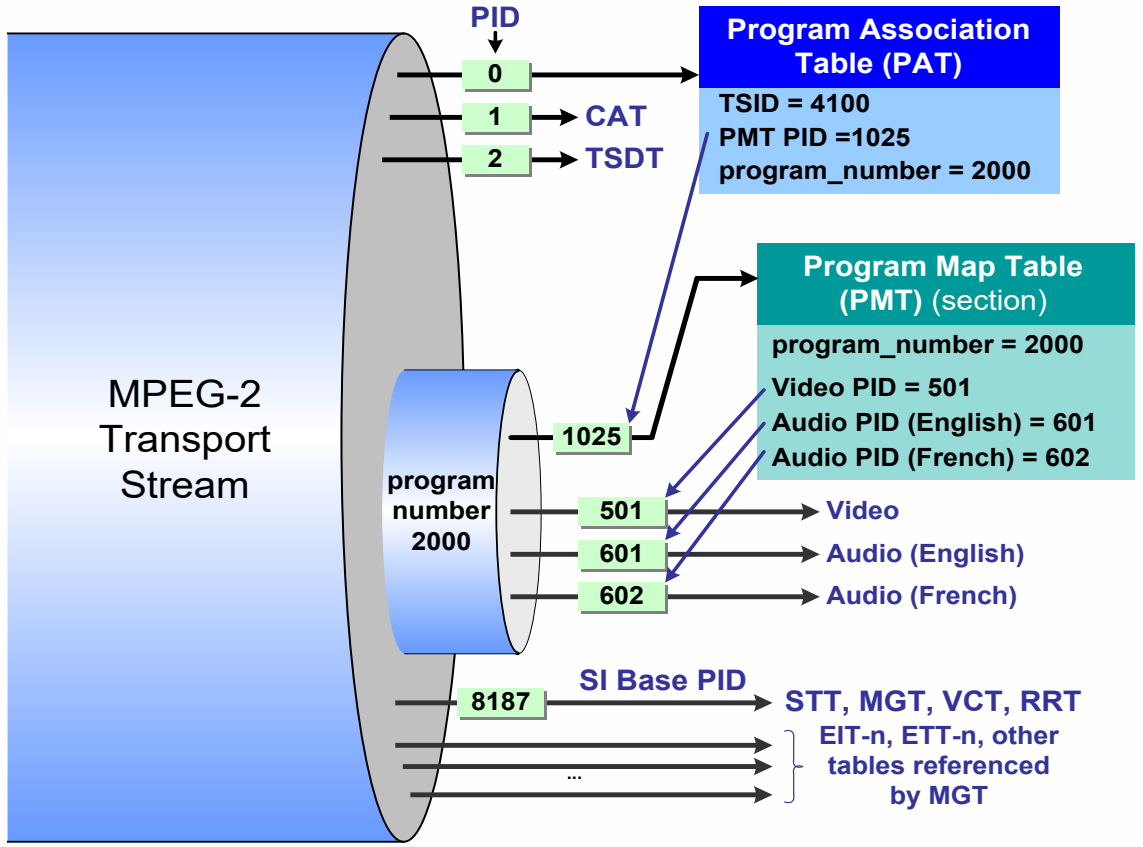
NTSC Broadcast System (Analog Television)

- Very successful technical standard
  - More than 60-year lifetime
- NTSC uses a 6 MHz RF channel
  - One video stream – first monochrome, then compatible color
  - One audio stream – first mono, then stereo, and later SAP added
  - Closed captioning



ATSC 1.0 – Television Goes Digital

- Digital transition is mandated by FCC
- Goal: free up spectrum resources
  - More on that later…
- ATSC is formed to create the new system
- Retrospectively dubbed ATSC 1.0 (aka A/53)
  - Single 6MHz RF channel
  - Digital – fit within 19.39 Mb/s
  - Multiple “programs”
  - HD Video
  - One Video per program
  - Multiple Audios
  - Closed Captioning



ATSC 1.0 in Perspective

Computer
DOS … Windows 3.1

Dial-up Modem
19.2 kbps

Cell Phone
Analog 2G

VCR - analog

About ATSC (Advanced Television Systems Committee)

Standards development organization for digital television

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

ATSC is an open, due process organization

- Approximately 180 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.

ATSC Members

BROADCASTING THE FUTURE

ATSC

ATSC Members - Continued

Digital Terrestrial Broadcasting SDOs

- ATSC (Advanced Television Systems Committee)
  - Based in the United States
  - Primarily deployed in USA, Mexico, Canada, South Korea, Dominican Republic
- DVB (Digital Video Broadcasting)
  - Based in Europe
  - Primarily deployed in Europe, Africa, much of Asia (except China, South Korea and Japan), Australia, New Zealand and more
- ARIB (Association of Radio Industries and Businesses)
  - Based in Japan
  - Primarily deployed in Japan and most of South America
- NRTA (National Radio and Television Administration)
  - Based in China
  - Primarily deployed in China

Career Sidebar: Opportunities in Standards Development

- Most people working in standards do not work for an SDO; they work for a company with a material interest in the standard being developed; some examples:
  - ATSC: Samsung, Fox Television Stations, Dolby Digital
  - 3GPP: Qualcomm, Nokia, Samsung
- Within larger companies, there can be many people working within many standards bodies
  - For example, Qualcomm may have hundreds of people working on the 5G standard within 3GPP and also have people working on ATSC topics; sometimes these are the same people
- People involved in standards development can participate within the standards process itself, or work behind the scenes, such as on patent development
- Those that participate in the standards process typically have many of the following skills:
  - Deep understanding of the technology
  - Great communications skills – written and oral
  - Good instinct for consensus building
  - Those that display leadership skills are often asked to Chair one or more groups
- Why work in standards?
  - Great networking – you'll know everyone, and everyone will know you
  - Be on the vanguard of "the next big thing"
  - Create a niche role for yourself within your field
  - Growth opportunities – larger companies have hierarchical structures for organizing their SDO efforts

Tips for getting involved:

- Learn about your employer's standards activities
- Listen in on standards conference calls
- Join standards bodies as an individual
- Go to SDO conferences even on your own dime if needed

Goals of ATSC 3.0

To add value to the broadcasting service platform	Enables new business models	Re… 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

Key Goal:
It's not just about television anymore.

BROADCASTING THE FUTURE

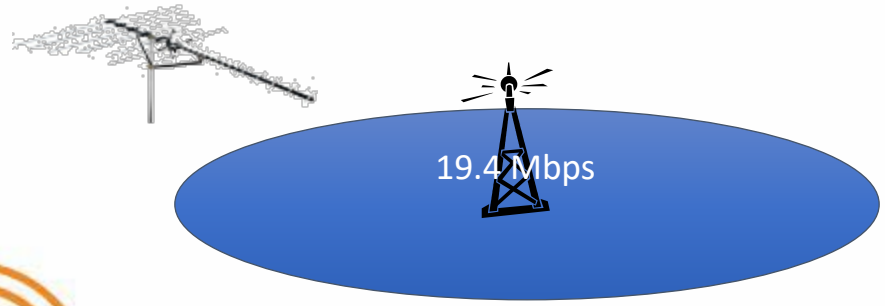
ATSC

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

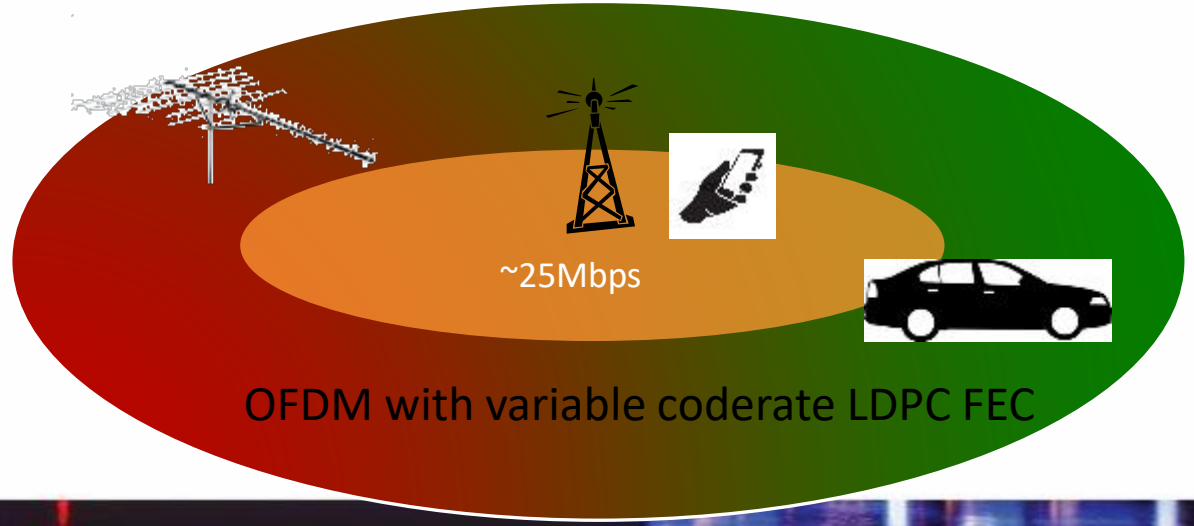
PHY/Comparison

- ATSC 1.0 physical layer
  - 8 level Vestigial Sideband modulation
  - Reed-Solomon Forward Error Correction (FEC)
  - One bit rate – 19.39 Mbps
  - One coverage area – 15 dB CNR (rooftop)
  - Gap-filling with echo-cancellation considerations
  - Service flexibility – HDTV, multicast, data

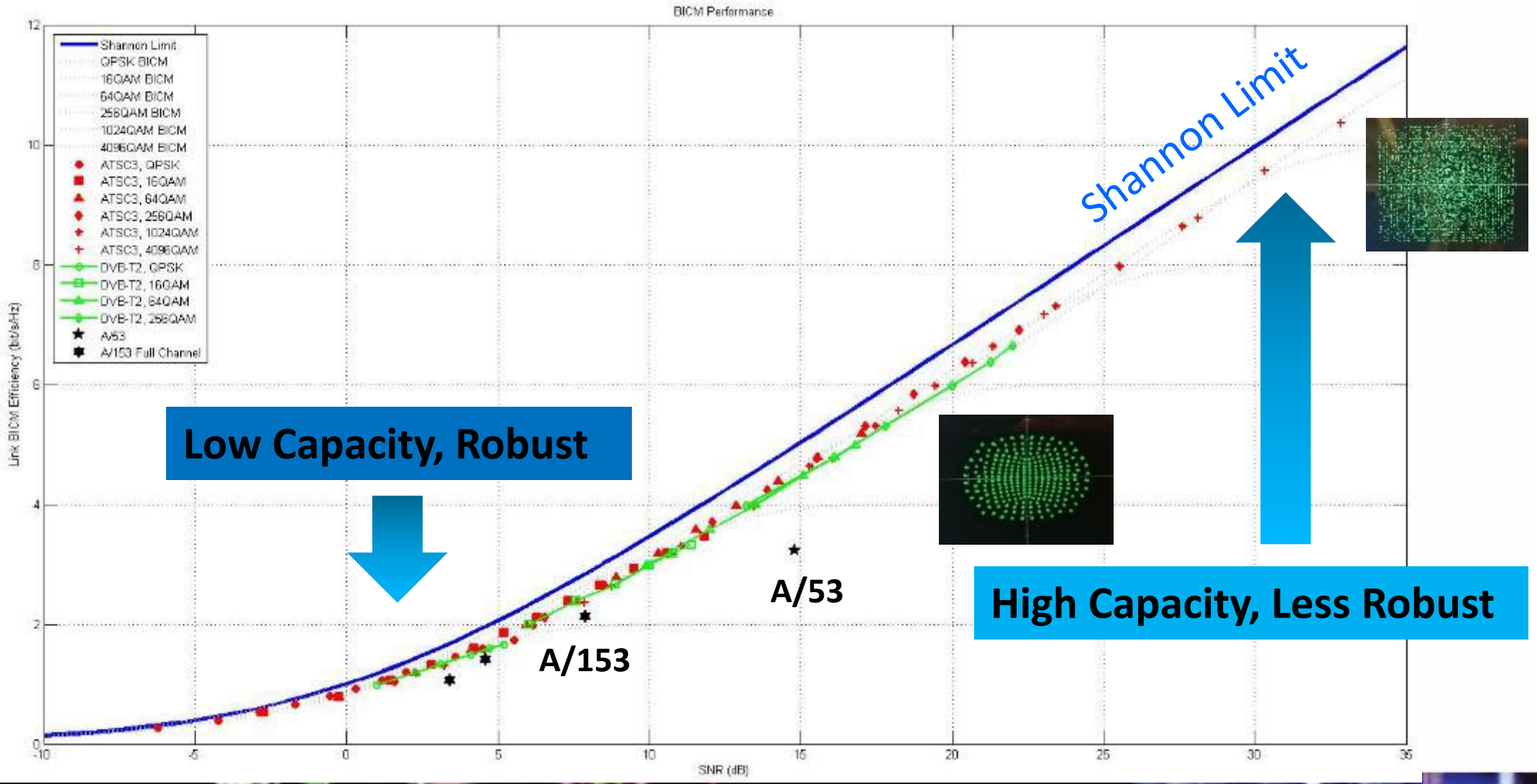


8-VSB with fixed (188,210) RS FEC

- ATSC 3.0 physical layer
  - Orthogonal Frequency Division Multiplexing Modulation
  - LDPC FEC (more powerful correction, sharper roll-off)
  - More bps/Hz – near theoretical limit
  - Flexible bit rate and coverage area choices
  - Enable on-channel repeaters and SFN for robust indoor and mobile reception with power-add considerations
  - Multiple simultaneous “Physical Layer Pipes”



Physical Layer Flexibility

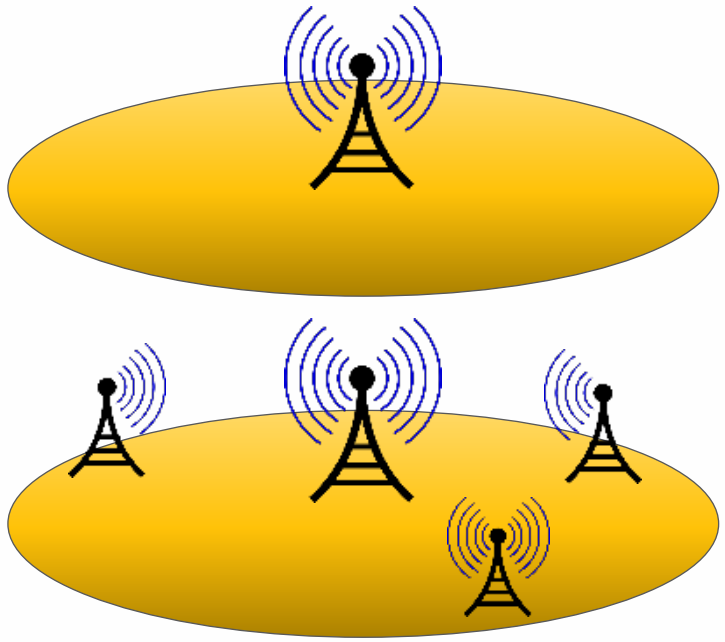


BROADCASTING THE FUTURE

ATSC

Single Frequency Networks

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



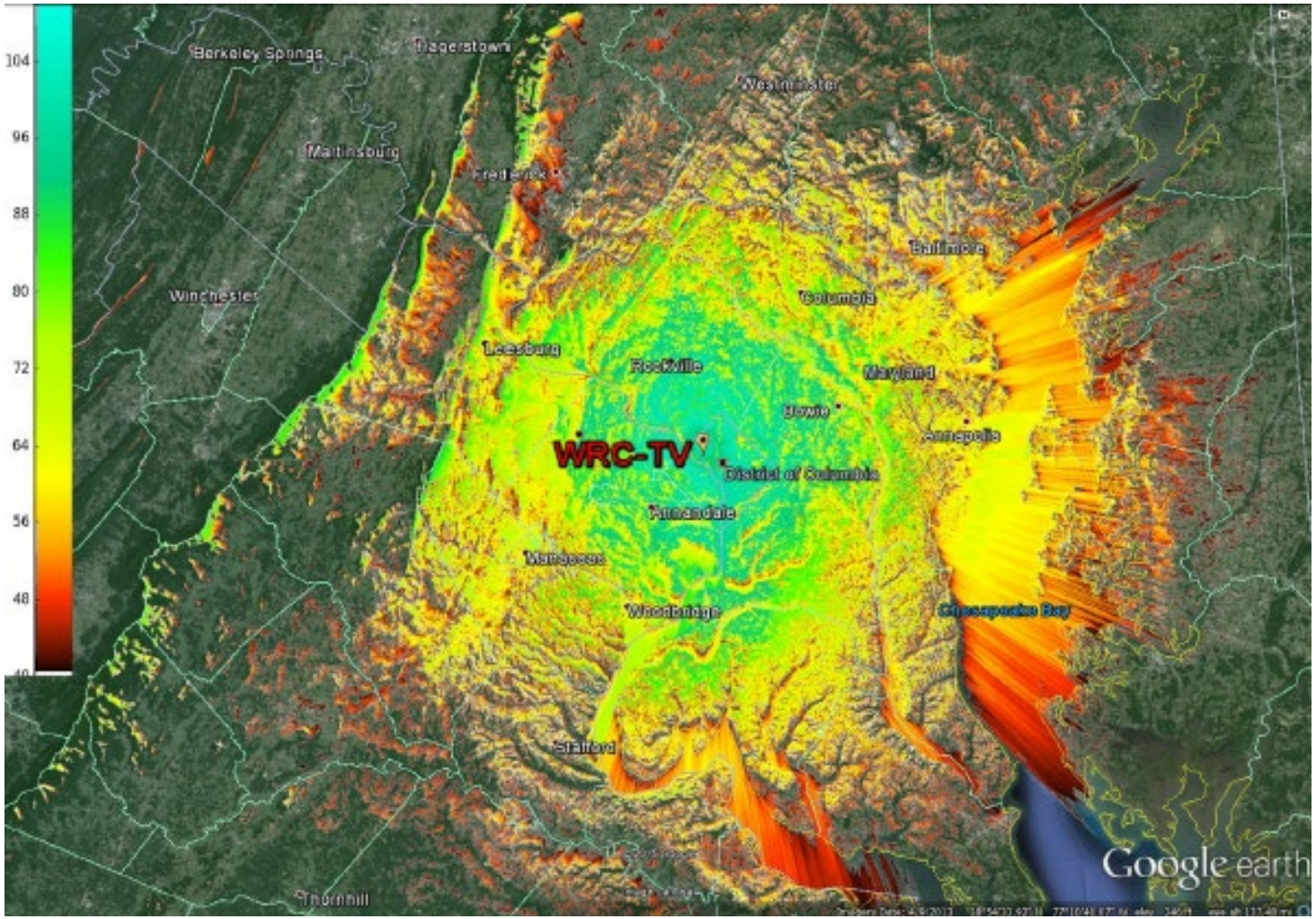
SFN with multiple transmitters increases coverage by boosting SNR in coverage holes

Multiple transmitters in an SFN can extend coverage and/or add capacity by raising SNR.

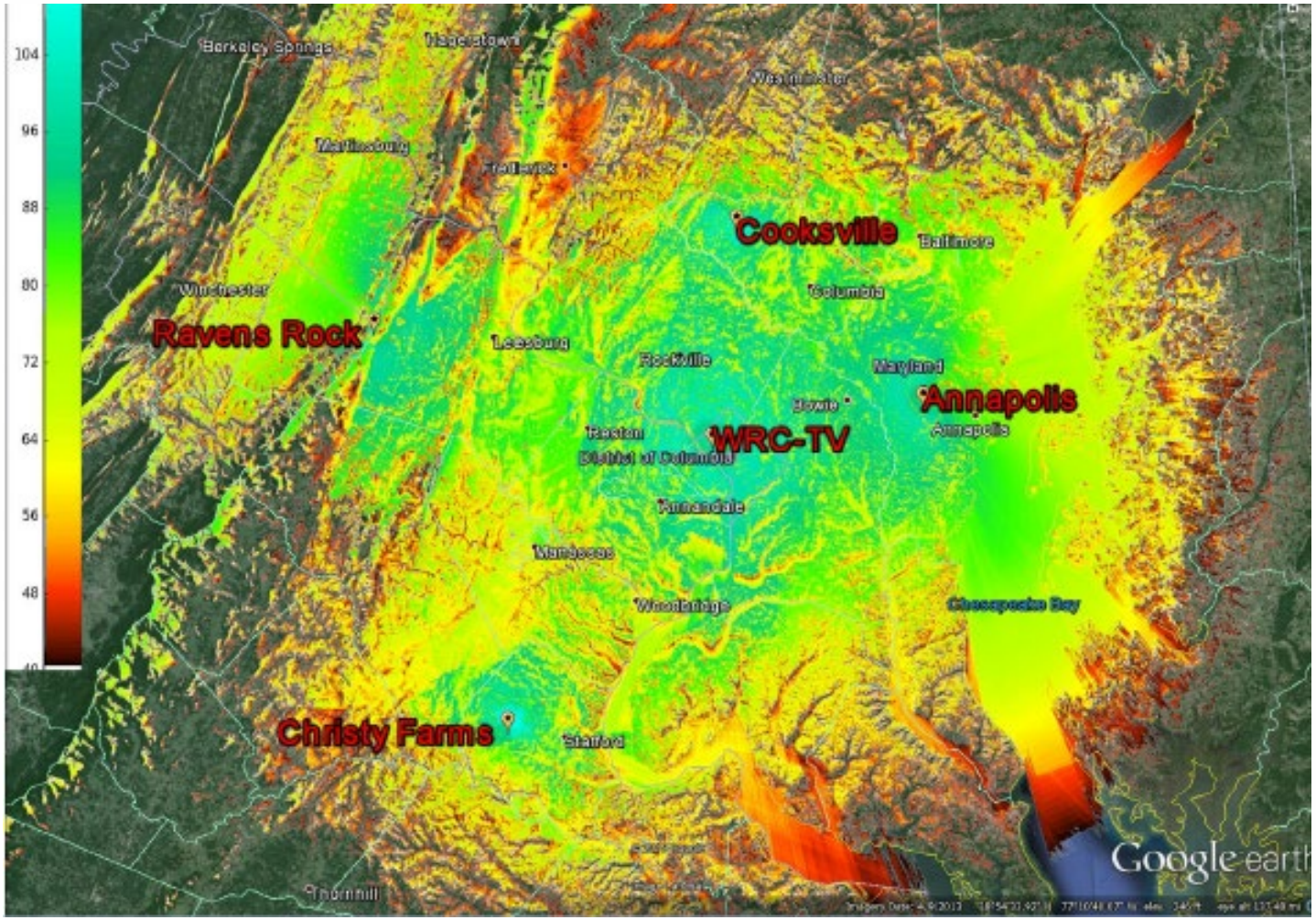
OFDM (Orthogonal Frequency Division Multiplexing) guard interval alleviates potential inter-symbol interference arising from multiple transmitters.

MISO (Multiple Inputs, Single Output) can be used to artificially de-correlate signals from multiple transmitters to avoid destructive interference.

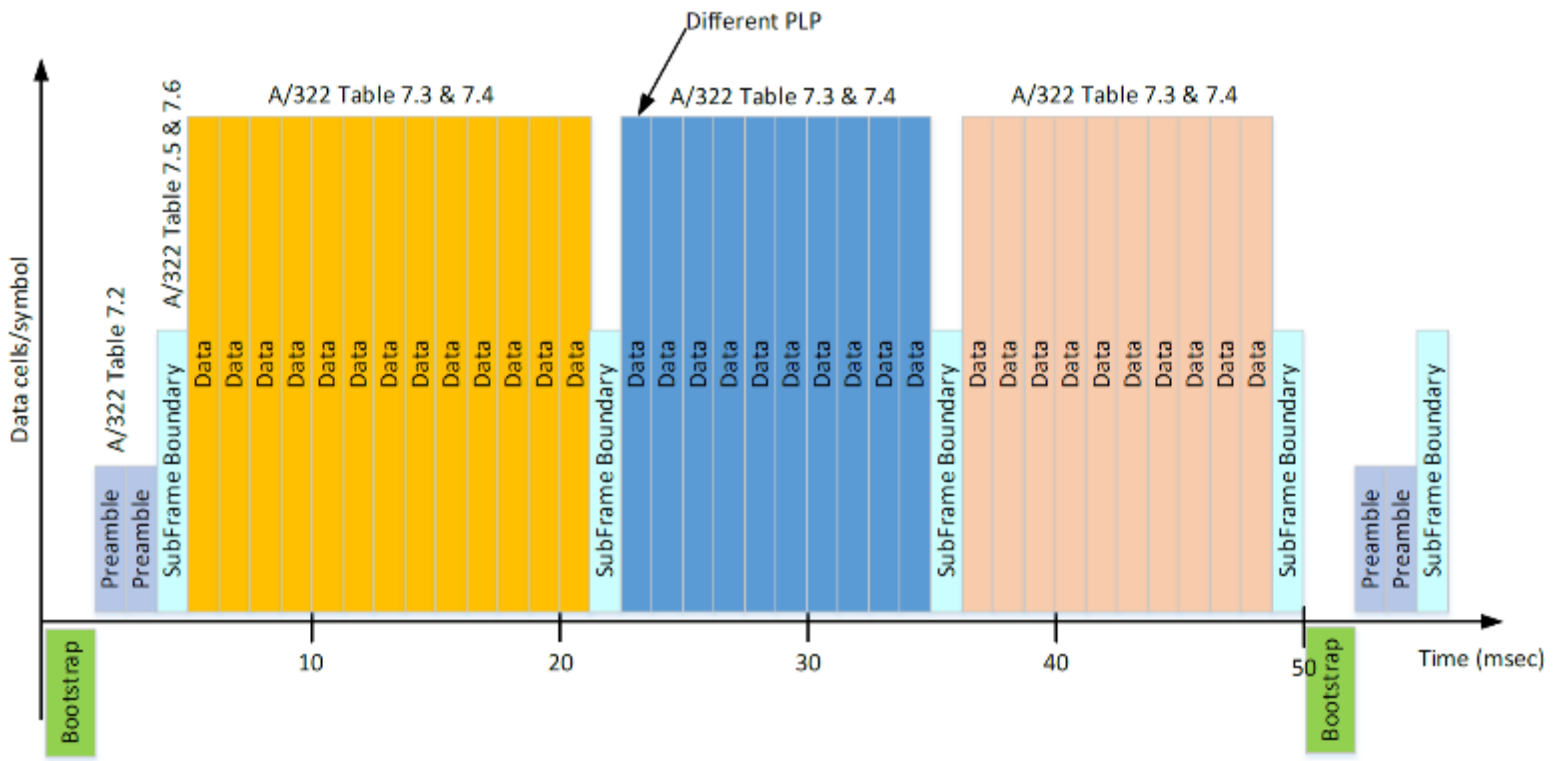
Washington, DC without SFN (example)



Washington, DC with SFN (example)

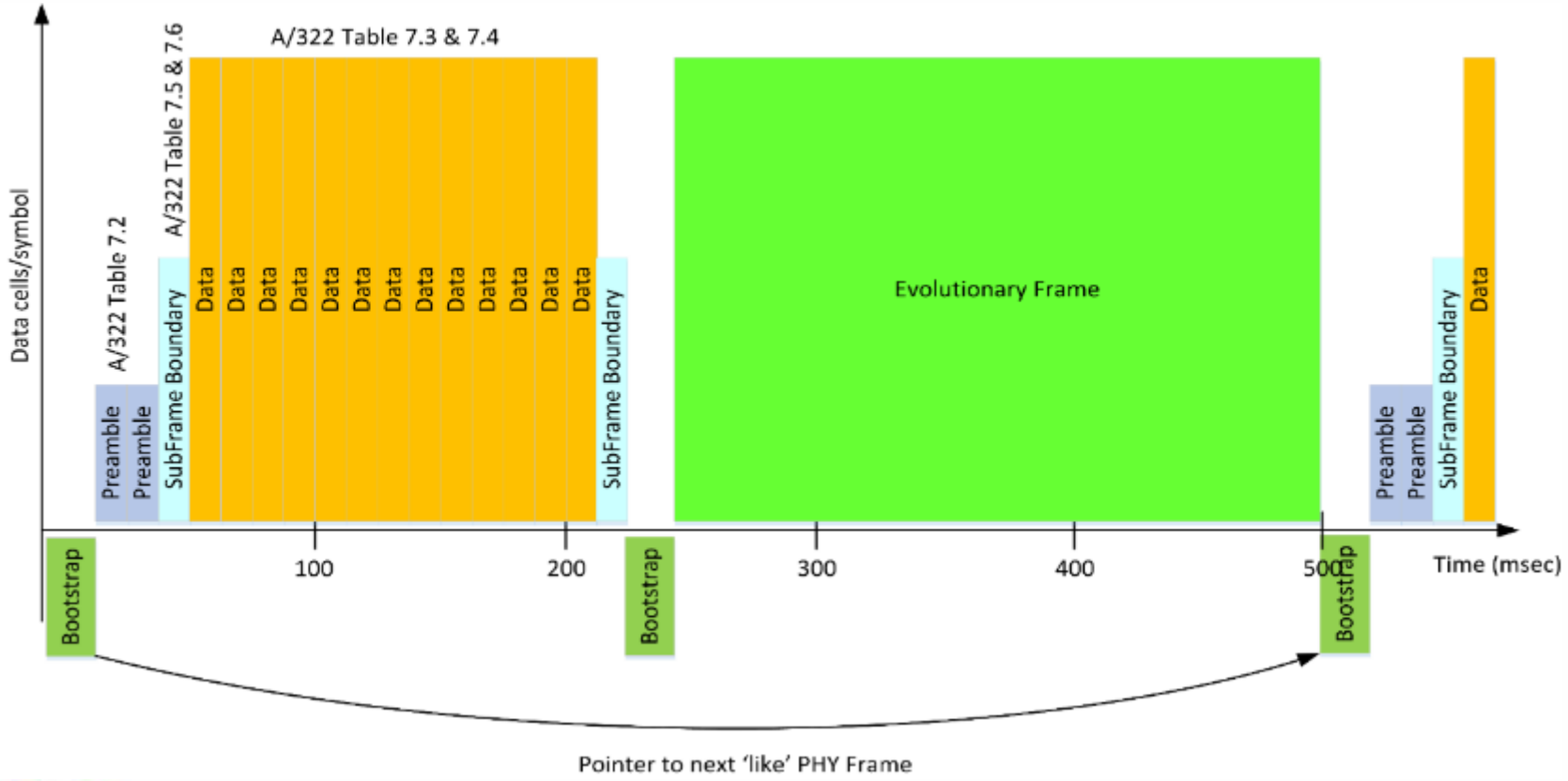


ATSC 3.0 Physical Layer Frame



- Example:
  - Three PLPs
  - Time Division Multiplex
- Frequency Division Multiplex and Layer Division Multiplex (2 layers) are also possible

ATSC 3.0 Bootstrap Enables Evolution



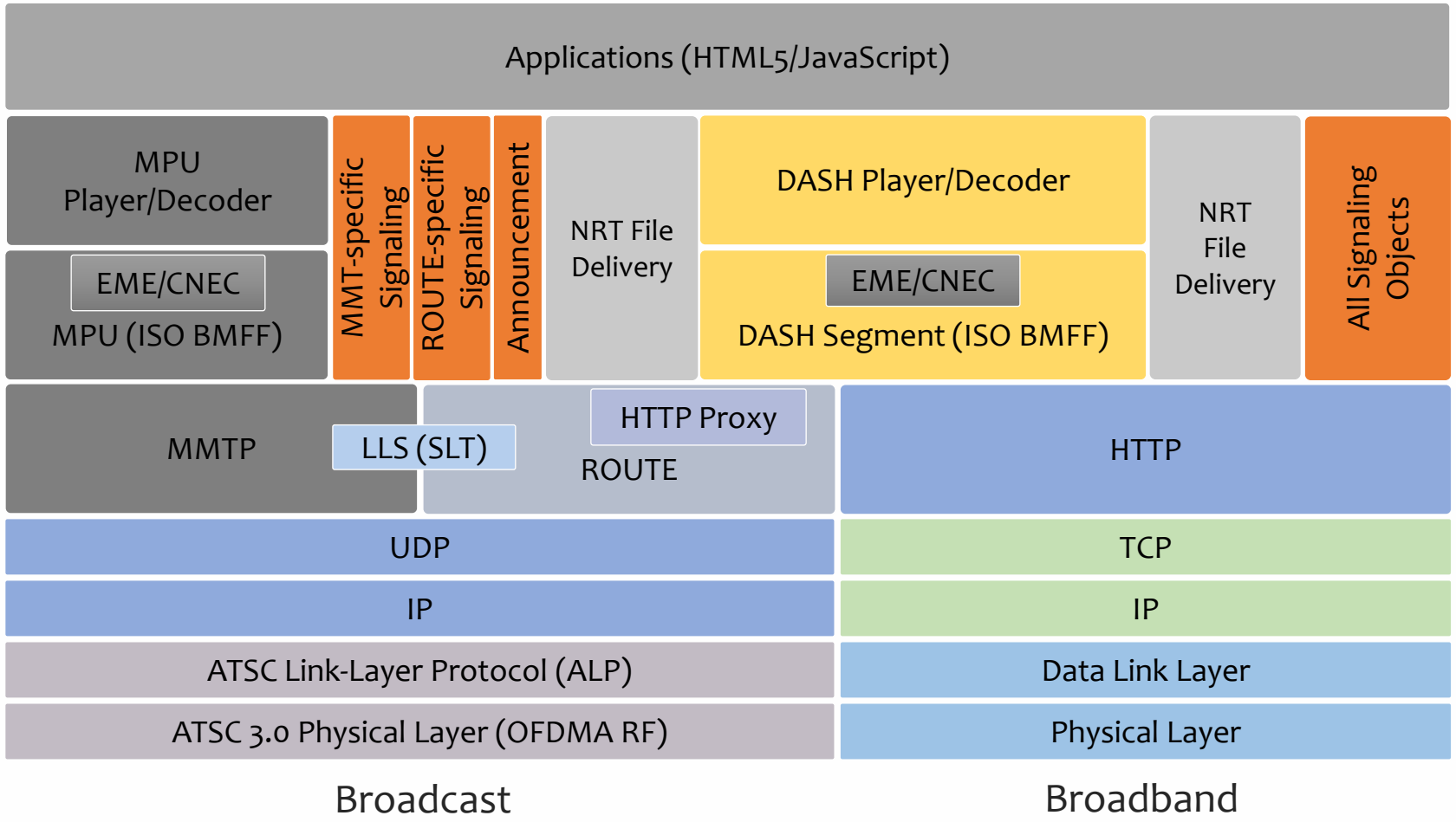
- Interleave next-next gen frames with ATSC 3.0 frames
- Bandwidth is shared between the two systems
- Receivers pick up the frames they "understand" and skip those they don't

Physical Layer Benefits

- ATSC 3.0 standard enables many system options for broadcasting industry (not just system parameter options)
- Hierarchical control signaling of physical layer parameters provides robust yet efficient communication of waveform configuration
- High robustness, spectrally efficient operating points
- Flexible configuration of operating modes with large SNR range
  - Allow choices of robustness and high capacity
  - Enable different services of different robustness to be multiplexed together
- Very robust synchronization with signaling of basic system parameters to allow for future technology advances
- Many flexible functions (framing, time interleaving, etc.) for optimization per broadcaster

ATSC 3.0 Transport Layer

- The ATSC 3.0 is currently the only DTT standard that specifies IP Transport; this enables many convergence scenarios between ATSC 3.0 and other IP-based networks.
- (ATSC 1.0 and all other DTT systems use MPEG2-TS, rather than IP.)



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

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

ATSC 3.0 Accessibility

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

ATSC 3.0 Interactivity: HTML5

HTML5: **H**yper**T**ext **M**ark-up **L**anguage, 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

ATSC 3.0 Interactivity: CSS

- 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;
  }
```

ATSC 3.0 Interactivity: 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

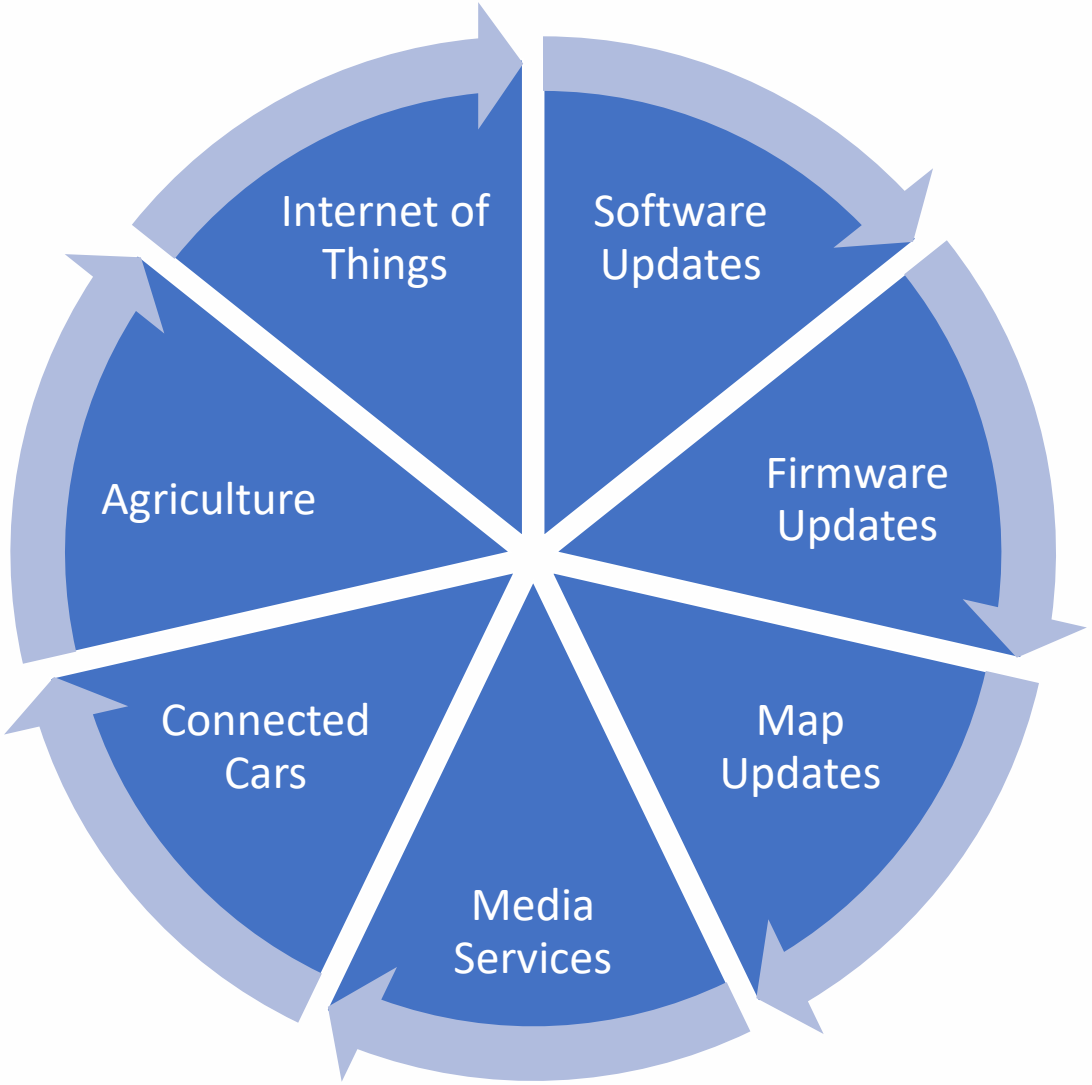
```
<button id="hellobutton">Hello</button>
  <script>
    document.getElementById( 'hellobutton‘ ).onclick = function() {
      alert('Hello world!');                  // Show a dialog
      var myTextNode = document.createTextNode('Some new words.');
      document.body.appendChild(myTextNode);   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

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

Data-casting as a Service

- ATSC 3.0 is a large digital data delivery pipe
- SFN enables operation as a wireless nationwide data delivery network
- Terrestrial broadcast can compete with other data delivery networks on price and service level for one-to-many use cases
- It’s not just about television any more



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”

Major Ongoing ATSC 3.0 Projects

CMAF
- Ongoing work in Video, Audio, Captions and signaling groups

VVC
- Brazil has selected this codec for its TV 3.0 project
- DVB has added VVC to its suite of standards

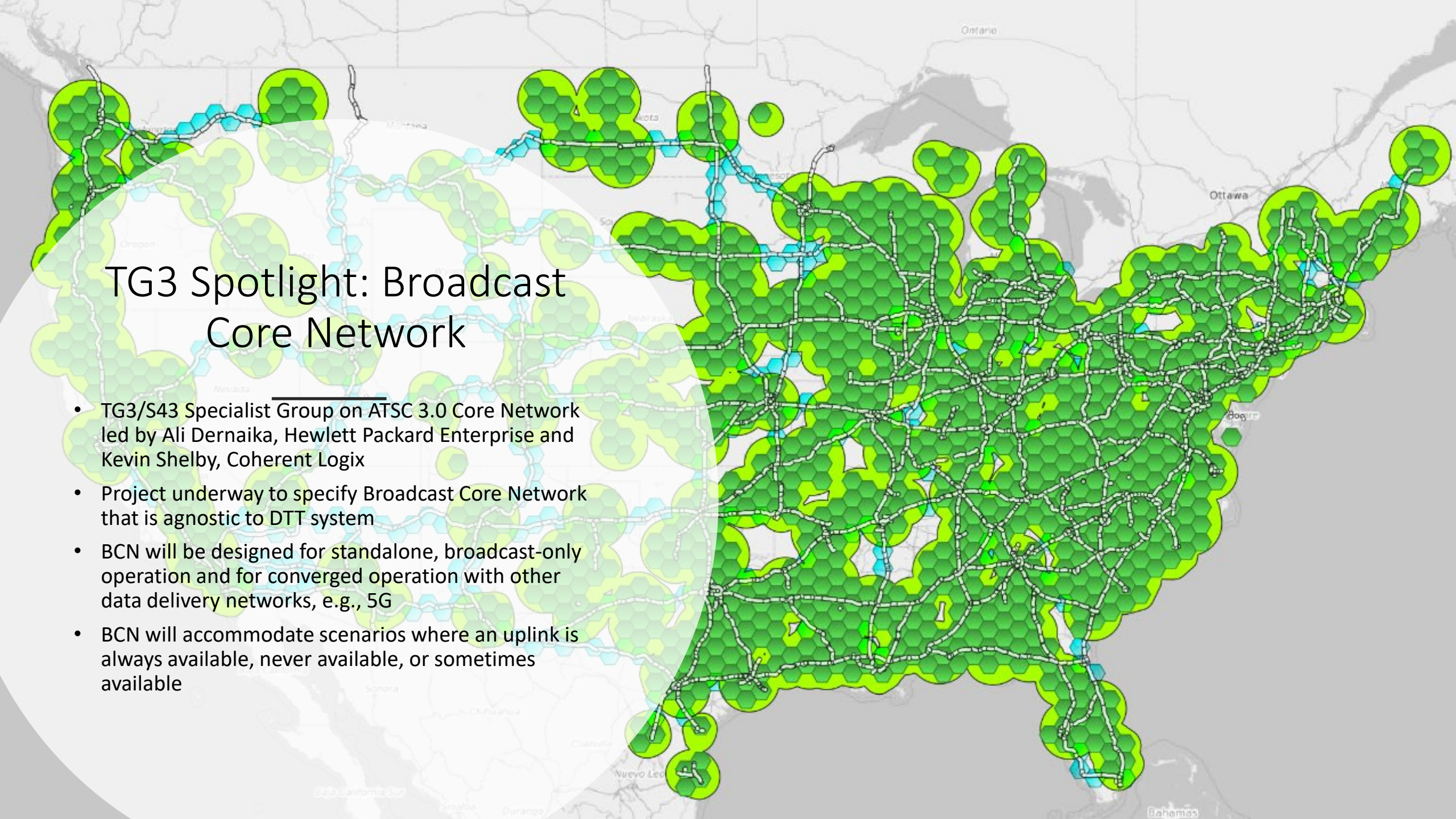
Broadcast Core Network
- RAN-agnostic core network capable of operating in downlink-only mode or two-way mode (using DTT for downlink and another network for uplink)

ATSC 3.0 / 5G Harmonization
- Documenting various potential technical architectures for ATSC 3.0 and 5G interoperation

Inter-Tower Communications Network
- Developing methods for delivering data between and among towers as a possible alternative to microwave or fiber links to transmitters

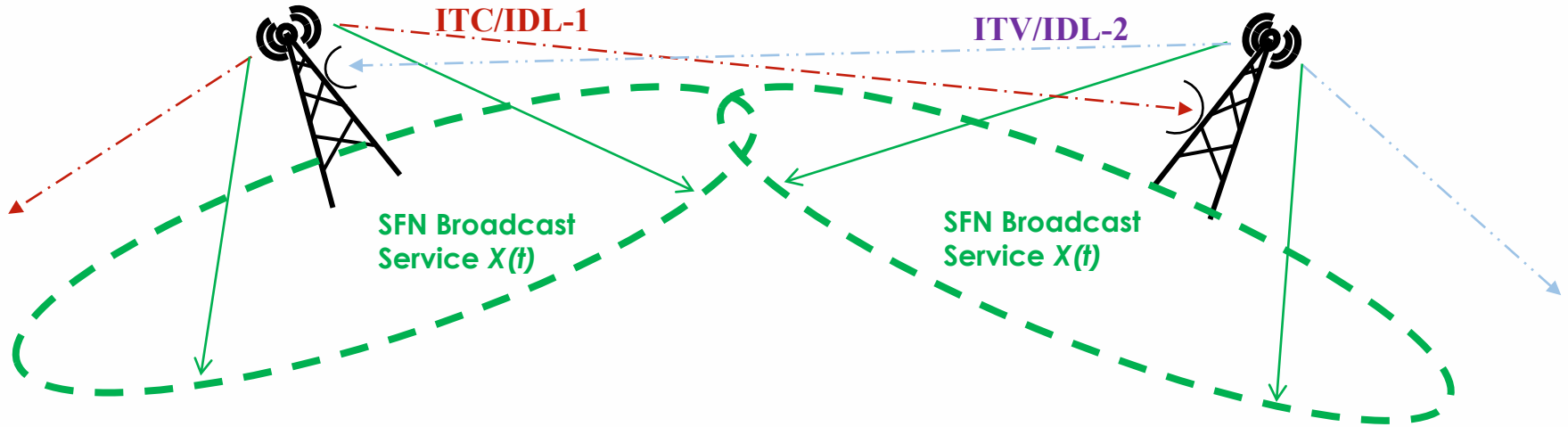
TG3 Spotlight: Broadcast Core Network

- TG3/S43 Specialist Group on ATSC 3.0 Core Network led by Ali Dernaika, Hewlett Packard Enterprise and Kevin Shelby, Coherent Logix
- Project underway to specify Broadcast Core Network that is agnostic to DTT system
- BCN will be designed for standalone, broadcast-only operation and for converged operation with other data delivery networks, e.g., 5G
- BCN will accommodate scenarios where an uplink is always available, never available, or sometimes available



Implementation Team Spotlight – Tower Network

- IT-5, Tower Network Implementation Team, led by Yiyan Wu, Canadian Research Center
- Work is underway to test and validate an inter-tower communications network (ITCN)
- ITCN will enable for both one-way and two-way communications among broadcast towers
  - Single Frequency Network scenario: HPHT transmits backhaul data to smaller towers in an SFN
  - “Mesh” network scenario: Two-way communications among any number of towers; full duplex
- Line-of-sight and professional grade transmitters and receivers optimize efficiency and minimize bandwidth needed for inter-tower data transmission



Broadcasting has a Key Role in a Data-Hungry World

The global HPHT infrastructure allows for sustainable transmission of point-to-multi-point services, which can include television and non-television use cases

Broadcast can fill an important role in a heterogeneous “network of networks”

- Select the most efficient network for the given use case
- Many uses cases are ideal for broadcast

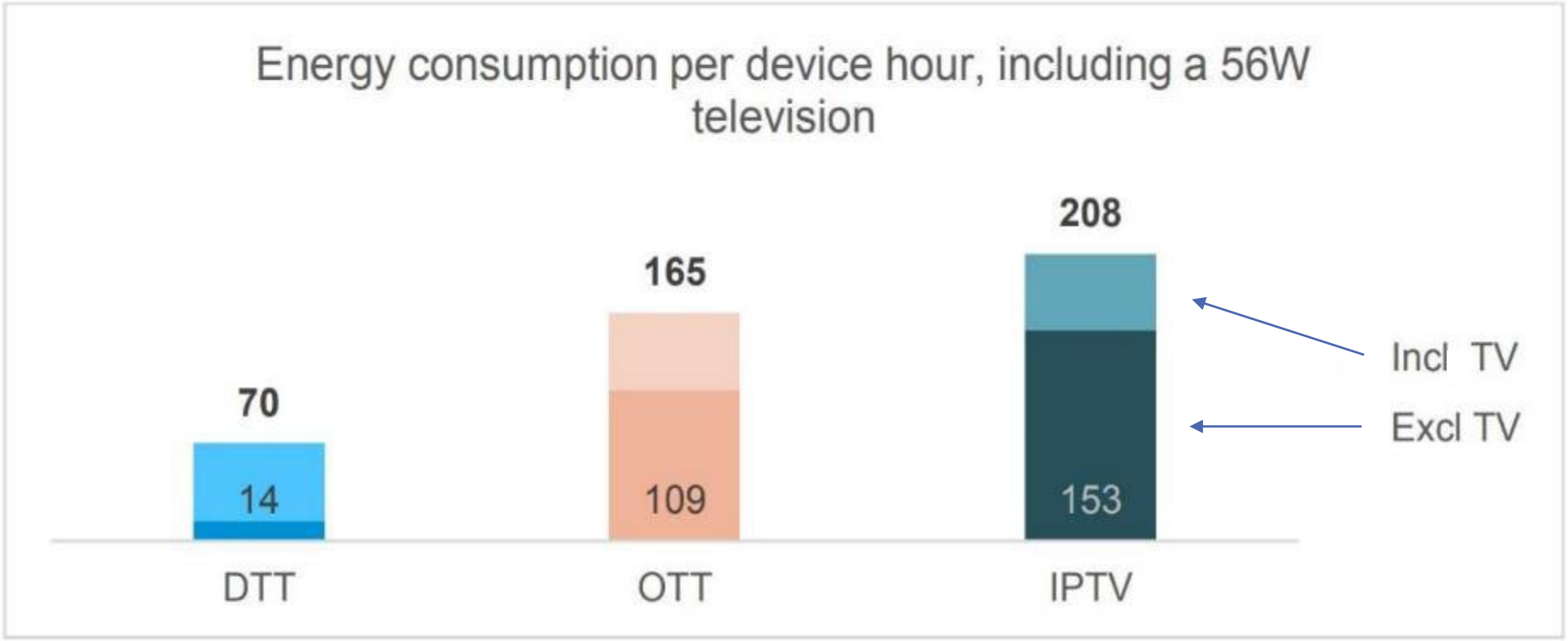
The global DTT community can work together to find common interfaces between the different DTT RANs and other global unicast networks

- Facilitate broadcast’s place in a heterogeneous “network of networks”
- Abstraction layers such as Broadcast Core Network and DVB-I can be explored as connecting points between global unicast networks and the various DTT networks
- Other opportunities for convergence between DTT systems can be identified and evaluated on a case-by-case basis

ATSC welcomes opportunities for collaboration as we work together to solidify the role of broadcasting in today’s media and data delivery landscape

Opportunity to Make a Difference

"…(T)he energy consumption and associated emissions of DTT are an order of magnitude lower than estimates for OTT and managed IPTV."



Quantitative Study of the GHG Emissions of Delivering TV Content
Carnstone/The LoCAT Project
Final Report, v1.1, September 2021

Terrestrial Broadcasting in a Mobile World

- 3rd Generation Partnership Project (3GPP) develops the standards used for mobile phones (2G, 3G, LTE/4G, 5G)
- 3GPP standards are largely designed for 2-way, one-to-one data communication – aka Unicast
- DTT standards are largely designed for 1-way, one-to-many data communication – aka Broadcast
- Broadcast mode is the most efficient way to deliver large amounts of data to many devices at the same time
  - The number of devices a given Broadcast can serve is, essentially, infinitely scalable
- Unicast mode is the most efficient way to deliver smaller amounts of data to fewer devices at different times
  - Each connection requires its own data feed, even if people are consuming the same content at the same time
- Live sports/news, SW/FW/map updates – good candidates for broadcast
- Video on demand, calls, texts – good candidates for unicast

Scenario: Traffic Offload

- Sinclair Broadcast Group, Saankhya Labs and TSDSI (India's Telecom SDO) are exploring Traffic Offload for India
  - India has 1.2 billion cell phones
  - People routinely watch linear television content on their phones
  - The Indian cellular network is facing major congestion issues; cell phone ownership and data usage is continually rising
- Concept:
  - "Smart" network core monitors the number of devices receiving the same data at the same time on LTE/5G network
  - When the number of devices exceeds a threshold, data delivery is moved off LTE/5G and onto ATSC 3.0 DTT network
  - No simulcast – bandwidth savings is the goal
- Indian operators are experimenting with the 3GPP broadcast mode (eMBMS), while also exploring ATSC 3.0
  - Today, ATSC 3.0 out-performs eMBMS for broadcast efficiency
  - Cellular operators in India may prefer to utilize the DTT spectrum in order to preserve their spectrum for unicast services
  - ATSC 3.0 tuner/demodulation would have to be added to the phones
  - Regulations would have to permit this usage on the DTT spectrum

Career Sidebar:

Next Gen Broadcast Requires Next Gen Skills

- RF Engineering
- Web Development
- IP Network Engineering
- Big Data Analysis
- Cyber Security
- Journalism
- Standards Development
- Cloud Infrastructure Development
- Virtual Network Development
- Storytelling
- Color Science
- Compression Algorithms
- AND MORE…

Summary

- ATSC is one of four digital terrestrial television standards development organizations worldwide
- ATSC 3.0 is the newest digital terrestrial television standard
  - Designed for TV and non-TV uses
  - Designed with fixed and mobile receivers
  - Designed for convergence with other data delivery networks, e.g., Internet, LTE/5G
- ATSC 3.0 specifies the most efficient physical layer for one-to-many data delivery in the world today
- Deployment and development are on-going for ATSC 3.0 with the goal of supporting and advancing the broadcast industry ecosystem
- There is much work to be done in the field – and great opportunities – both commercial and technical

Thank you

Q&A