Detroit SMPTE
ATSC 3.0 Technical Overview

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What is ATSC 3.0?

- ATSC 3.0 is the next generation terrestrial broadcast system designed from the ground up to improve the television viewing experience with higher audio and video quality, improved compression efficiency, robust transmission for reception on both fixed and mobile devices, and more accessibility, personalization and interactivity. The ATSC 3.0 standard is defined in a suite of more than 20 Standards and companion Recommended Practices.

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ATSC 3.0 Standards Tower

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Advantages of ATSC 3.0?

- Built on the same Internet Protocol backbone as today's popular streaming media platforms
- Designed to bring together Over-the-Air with Over-the-Top content
- Delivers better video quality and immersive audio to viewers
- Provides the capability of Advanced Emergency Alerting and Informing
- Easily adaptable for future technologies

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Why The Change?

- The ATSC 1.0 system developed in the early 1990’s to replace NTSC.
- Although good for the time has become outdated over the last 30 years.
- Incompatible with mobile.
- Broadcasters need to have products and services to compete with advanced products offered by broadband and mobile providers.

ATSC 3.0 Benefits

- Scalable encoding
- Mobile
- Supports 4K, UHD, High Quality Audio
- Enhanced Dialog, 7.1 Audio
- Targeted Content
- IP based Standard, allows for evolution
- Offers Signal Signing & Encryption
- Significantly improved Emergency Alerting (AEA&I)

Common Terms and Abbreviations

- ROUTE-Real-Time Object Delivery over Unidirectional Transport
- MMT-MPEG Media Transport
- DASH-Dynamic Adaptive Streaming over HTTP
- BSID-Broadcast Stream Identifier
- ESG-Electronic Service Guide
- AEA-Advanced Emergency Alerting
- LCT-Layered Coding Transport
- LLS-Low Level Signaling
- SLS-Service Level Signaling
- SLT-Service List Table
- TAI-International Atomic Time
- HEVC-High Efficiency Video Codec

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Encoder/Packager

- HEVC & AC4
  - 1080p at 4-5 Mb/s
  - UHD at 16 Mb/s
  - 480p at <1 Mb/s
  - Internal AC4 encoder up to 5.1
  - AC4 allows 7.1, but that must be done before the encoder
  - AC4 also allows for enhanced dialog and multiple languages by replacing the center channel.
- DASH Packaging
  - DRM
  - IMSC1 Captions
  - OTT

ROUTE/MMT Server

- DASH to ROUTE conversion
  - DASH is a file transfer and must use unicast rules from encoder to ROUTE server
  - ROUTE is multicast
- ESG Generation
  - Must be able to go out to external FTP (TitanTV, GraceNote, etc)
  - For a Lighthouse model, partner guide data must be aggregated somewhere.
- Signaling Generation
- Broadcast App Insertion
  - Broadband or Broadcast
- AEA-Advanced Emergency Alerting.
  - Must use a Broadcast App for TV to show this
- NRT Data
- Signal Signing

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Gateway

- ROUTE to STLTP Conversion
- Unreferenced Data Insertion
- ModCod/Exciter Settings
- LDM-Layered Division Multiplexing
  - Advantage is that it can allow more bandwidth in a defined modulation and code rate scheme for PLP-0. You have to give up a certain amount of C/N in PLP-1 though. Typically 1 to 1.5 dB.

ModCod Overview

- General Rules
- LLS/Preamble
- Subframe
- PLP
- Modulation
- Scattered Pilot
- Guard Interval
- Code Rate
- CTI vs HTI

ModCod General Rules

- PLP-0 must be the most robust and contain the LLS
- Singular Subframe delay must be >20mS. Total subframe delay must be <250mS
- CTI is used for one PLP. HTI for multiple PLPs.
- Longer time interleaver equals more time diversity which is best. So use TI=1 in PLP-0 when in HTI mode
- C/N for cell phones is 3-5 dB. Smaller cells, but works well indoors. ATSC 1.0 C/N is 15 dB. Mobile PLP-0 should have a C/N close to 5 dB. Fixed PLP-1 should have a C/N close to 15 dB.
- Code Length 16k vs 64k. The longer the code word length, the higher the protection. At this point, I don't believe there is a reason to use 16k at all.
- Scattered Pilot- For the first bit, lower for mobile is better. For the 2nd bit, stationary devices can tolerate _4 but mobile should be _2.
- Less dummy cells is more efficient
- GI-this is directly related to the multipath you may have to deal with. The worst city in the US is San Francisco. You might need GI 1024 there. All other cities would be fine with 768. SFN changes this though, you may have to lengthen GI if the SFN transmitters are at the edge of coverage.
- https://atsc.agos.co.kr/ is a good online tool. Teamcast ATSC 3.0 Calculator is another good tool (excel based). I also use Triveni, Enensys, and DigiCAP Gateways to validate a ModCod.

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LLS & Preamble

- 224.0.23.60:4937
- Preamble mode. Mode 1 is the most robust and usually results in 2 preamble symbols. Mode 3 offers a nice middle ground balance between payload and robustness and results in 1 preamble symbol. Mode 3 is a nice tradeoff balance.
- Service List Table (SLT), Rating Region Table (RRT), System Time Fragment (SystemTime) based on the universal time clock (UTC)
- SLT references the SLS. There is an SLS per service transmitted.

Subframe

- <250mS total delay
- Number of symbols is directly related to delay. The more symbols, the more delay
- Symbols are also related to number of cells and bandwidth, but not linearly if using HTI.
- You can use one subframe if all PLPs will use the same GI and FFT size.
- If your PLP's will have different GI and FFT, then you need another Subframe for those different settings.

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PLP

- Physical Layer Pipe
- ATSC 1.0 has one, an 8VSB modulation with 19.392658 Mb/s bitrate.
- ATSC 3.0 allows for up to 4 PLP's. But most configs to date use one or two.
- The most robust PLP must be PLP-0 and it must have the LLS in it.
- We typically also put ESG in PLP-0
- Each can have completely different settings to suit the broadcast needs.

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Modulation

- QPSK, 16QAM, 64QAM, 256QAM, 1024 QAM, and 4096QAM are supported.
- Most launches use a 16QAM in PLP-0 and 256QAM in PLP-1.
- The higher the modulation, the more bitrate available but also the higher the C/N will be.

Scattered Pilot

- There is a SP for Preamble that may be different from the Subframes SP
- Both have rules about what can be used based on other settings.
- Some equipment and calculators allow you to chose invalid SP values.
- A list of available SP can be found in A322, page 97.
- The larger the SP number, the more bitrate.
- Try to get as high of Dx and Dy as possible for stationary services while keeping mobile services to having the pilot pattern repeat every other symbol (Dy=2).

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Scattered Pilot

GI Pattern	Samples	8K FFT	16K FFT	32K FFT
GI1_192	192	SP32_2, SP32_4, SP16_2, SP16_4	SP32_2, SP32_4	SP32_2
GI2_384	384	SP16_2, SP16_4, SP8_2, SP8_4	SP32_2, SP32_4, SP16_2, SP16_4	SP32_2
GI3_512	512	SP12_2, SP12_4, SP6_2, SP6_4	SP24_2, SP24_4, SP12_2, SP12_4	SP24_2
GI4_768	768	SP8_2, SP8_4, SP4_2, SP4_4	SP16_2, SP16_4, SP8_2, SP8_4	SP32_2, SP16_2
GI5_1024	1024	SP6_2, SP6_4, SP3_2, SP3_4	SP12_2, SP12_4, SP6_2, SP6_4	SP24_2, SP12_2
GI6_1536	1536	SP4_2, SP4_4	SP8_2, SP8_4, SP4_2, SP4_4	SP16_2, SP8_2
GI7_2048	2048	SP3_2, SP3_4	SP6_2, SP6_4, SP3_2, SP3_4	SP12_2, SP6_2
GI8_2432	2432	*N/A*	SP6_2, SP6_4, SP3_2, SP3_4	SP12_2, SP6_2
GI9_3072	3072	*N/A*	SP4_2, SP4_4	SP8_2, SP3_2
GI10_3648	3648	*N/A*	SP4_2, SP4_4	SP8_2, SP3_2
GI11_4096	4096	*N/A*	SP3_2, SP3_4	SP6_2, SP3_2
GI12_4864	4864	*N/A*	*N/A*	SP6_2, SP3_2

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FFT

- If mobile Service is desired, use 8K or 16K FFT. If only stationary Service is desired, any FFT size will do including 32K FFT. Higher payloads will come with 32K FFT.
- The larger the FFT size, the more bandwidth capacity you have.

Guard Interval

- It gets set in Preamble and must be equal to the GI in Subframe-0
- Other Subframes can have different GI values
- Using ATSC 1.0 as a guide, the longest echo seen in the field was in San Francisco when emissions would bounce off the Golden Gate Bridge and reflect back into the city. In that scenario, around 148 µsec of echoes were seen. Elsewhere in the US, echoes are usually less than 100 µsec. Setting the GI to 768 (111 µsec) should cover most markets for single stick operations. Only certain GI's are allowed per FFT size and I use A/322 Table 8.9 as a guide.

Guard Interval

GI Pattern	Duration in Samples	8K FFT	16K FFT	32K FFT
GI1_192	192	✔	✔	✔
GI2_384	384	✔	✔	✔
GI3_512	512	✔	✔	✔
GI4_768	768	✔	✔	✔
GI5_1024	1024	✔	✔	✔
GI6_1536	1536	✔	✔	✔
GI7_2048	2048	✔	✔	✔
GI8_2432	2432	*N/A*	✔	✔
GI9_3072	3072	*N/A*	✔	✔
GI10_3648	3648	*N/A*	✔	✔
GI11_4096	4096	*N/A*	✔	✔
GI12_4864	4864	*N/A*	*N/A*	✔

Code Rate

- Between 2/15 and 13/15
- The higher the first number, the more bandwidth but also the higher C/N needed to receive.

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CTI

- CTI is used when you have one PLP or LDM.
- It is straight forward, fill the PLP with as many cells as you can with a single cell resolution.

HTI

- HTI is used when there are multiple PLP’s
- More difficult to execute.
- You need to use TI Blocks and FEC Blocks to determine the number of cells you have available.

HTI Continued

- To find cells in HTI, you multiply 8100 x 93 FEC blocks= 753300.
- Why 8100? It's a formula (Code Length/Modulation Bits):

Code length	Modulation	Modulation bits	Cells
64800	QPSK	2	32400
	16 QAM	4	16200
	64 QAM	6	10800
	256 QAM	8	8100
	1024 QAM	10	6480
	4096 QAM	12	5400
16200	QPSK	2	8100
	16 QAM	4	4050
	64 QAM	6	2700
	256 QAM	8	2025
	1024 QAM	10	1620
	4096 QAM	12	1350

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Parameter	PLP0 (Mobile)	PLP1 (Stationary)
RF Center Frequency	575 (Channel 31)	
Subframe	0	1
FFT Size	8K	16K
Pilot Pattern	4_2	8_2
Pilot boost	1	
Guard Interval	G4_768 (111us)	
Preamble Mode	(Basic: 3, Detail: 3) Pattern Dx = 4	
Frame Length	193 msec	
# of Symbols	33	59
PLP size	194400 cells	753300 cells
Frequency Interleaver	On	On
Time Interleaver	Hybrid 12 FEC Blocks 1 TI Block (43.2 msec time spread)	Hybrid 93 FEC Blocks 3 TI Block (50.8msec time spread)
Modulation	16 QAM	256 QAM
Code Rate	7/15	11/15
Code Length	64K	
Contents	WMYD TV20 (VC 20.1) – lower res.	WXYZ (VC 7.1), WDIV (VC 4.1), WJBK (VC 2.1), WWJ (VC 62.1), WMYD TV20 (VC 20.1)
Bit Rate (Mbps)	1.87	23.60
Required C/N (dB) (Single diversity, AWGN)	5.28	18.91

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ATSC 3.0 Launch Overview

- BOM
- Block Diagram
- Budgetary Estimate for a ATSC 3.0 Lighthouse
- Market Connectivity
- Add On Technology

Bill of Materials

- HEVC & AC4 Encoder plus DASH Packager
- ROUTE and/or MMT Server
- Broadcast Gateway/Scheduler
- Stratum 1 NTP and GPS
- IP STL with around 35 Mb/s minimum capacity
- ATSC 3.0 IP and RF Analysis
- ATSC 3.0 IP and RF IRD
- Consumer TV
- IP Interconnect between stations (VideoFlow or LTN)

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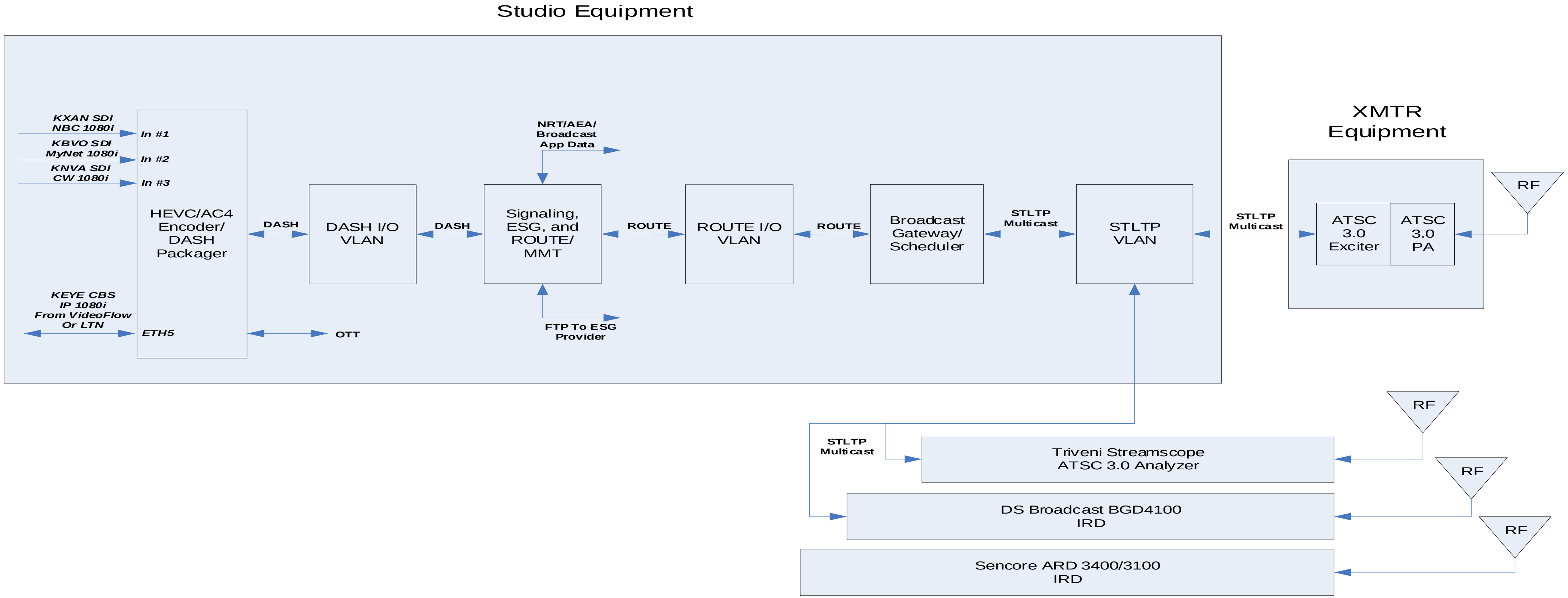
Block Diagram



Budgetary Estimate

- Encoder/packager $40-50k (depends on Mfg and ch count)
- ROUTE/Gateway $65000-90000 (depends on Mfg and ch count)
- Monitoring Equipment $65000 (Analyzer, IRDs, and consumer TV)
- Misc Equipment $15000 (Nielsen, GPS, NTP, etc.)
- IP STL $70000 (SAF Microwave for example)
- VideoFlow $15000 per site roughly

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Market Connectivity

- LTN
  - Managed Services
  - OpEx
- VideoFlow
  - CapEx
- Microwave
- Fiber

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Status update on Consumer Devices

- Samsung-Good A/V and ESG. Captions broke in version 2016. Certificates break the channel
- Sony-Good A/V, captions, ESG, and Certs
- LG-Good A/V, captions, ESG, and Certs
- HDHomeRun-Good video. Audio, captions, and ESG have issues. No DRM or Cert support yet.

Status and more about Signal Signing

- EONTI/DigiCert– Stations must contract with them and they will issue the certificates
- The Lighthouse owner needs to buy a cert for CDT and SMT. Possibly one for App Distribution as well
- Any App author needs to buy a cert for their app.
- Status-Cert issuance on hold until new OCSP Responder is in place.
- Sunrise to start then. High Noon a few months after.

Additional Technologies

- OTT
- UHD
- HDR
- DRM
- AEA
- Broadcast App
- Datacasting

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Reference Materials

- ATSC 3.0 Station Lighthouse Manual from Pearl
- ATSC 3.0 Standards (https://www.atsc.org/atsc-documents/type/3-0-standards/)

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Questions