RAVENNA 2020 Webinar Series

SMPTE ST 2110-31 Applications

Tue, Nov 17, 2020
16:00 h (CET)

Presenter: James Cowdery, Dolby Labs

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Your Host

Andreas Hildebrand, RAVENNA Technology Evangelist

- more than 25 years in the professional audio / broadcasting industry
- graduate diploma in computer science
- R&D, project & product management experience
- member of AES67 TG and ST2110 DG

ALC NetworX GmbH, Munich / Germany

- established 2008
- R&D center
- developing & promoting RAVENNA
- Partnerships with > 40 manufacturers

RAVENNA

- IP media networking technology
- designed to meet requirements of professional audio / broadcasting applications
- open technology approach, license-free
- fully AES67-compliant (*built-in*)

Our Guest

James Cowdery, Senior Staff Architect

- Joined Dolby in 2004
- Background in Digital Signal Processing Software
- Founded and managed Professional Licensing Engineering at Dolby
- Currently an architect focused on audio and metadata carriage over IP

Dolby Labs, San Francisco

- Established 1965 in London, UK
- Based in San Francisco with offices in over 20 countries
- Audio and video technology portfolio covers music, movies, TV, gaming and voice
- Deployed in billions of consumer devices worldwide
- Builds innovative technologies that enable creatives to inspire and move us all

Agenda

Andreas:

- Quick overview on AES67 / RAVENNA / SMPTE ST 2110
- Payload formats: L24 (24-bit PCM) vs. AM824 (AES3)

James:

- Review of SMPTE ST 337
  - Channel status bit use-cases in live broadcast - specifically audio bit
- Introduction to Dolby E in SMPTE ST 337/SDI, switching requirements
  - Packetization of Dolby E in Ravenna AM824/ST 2110-31 to enable packet-level switching
- Introduction to Metadata for next-generation audio production
  - New metadata datatypes
  - Example use cases using -30 for audio and Ravenna AM824/ ST 2110-31 for metadata

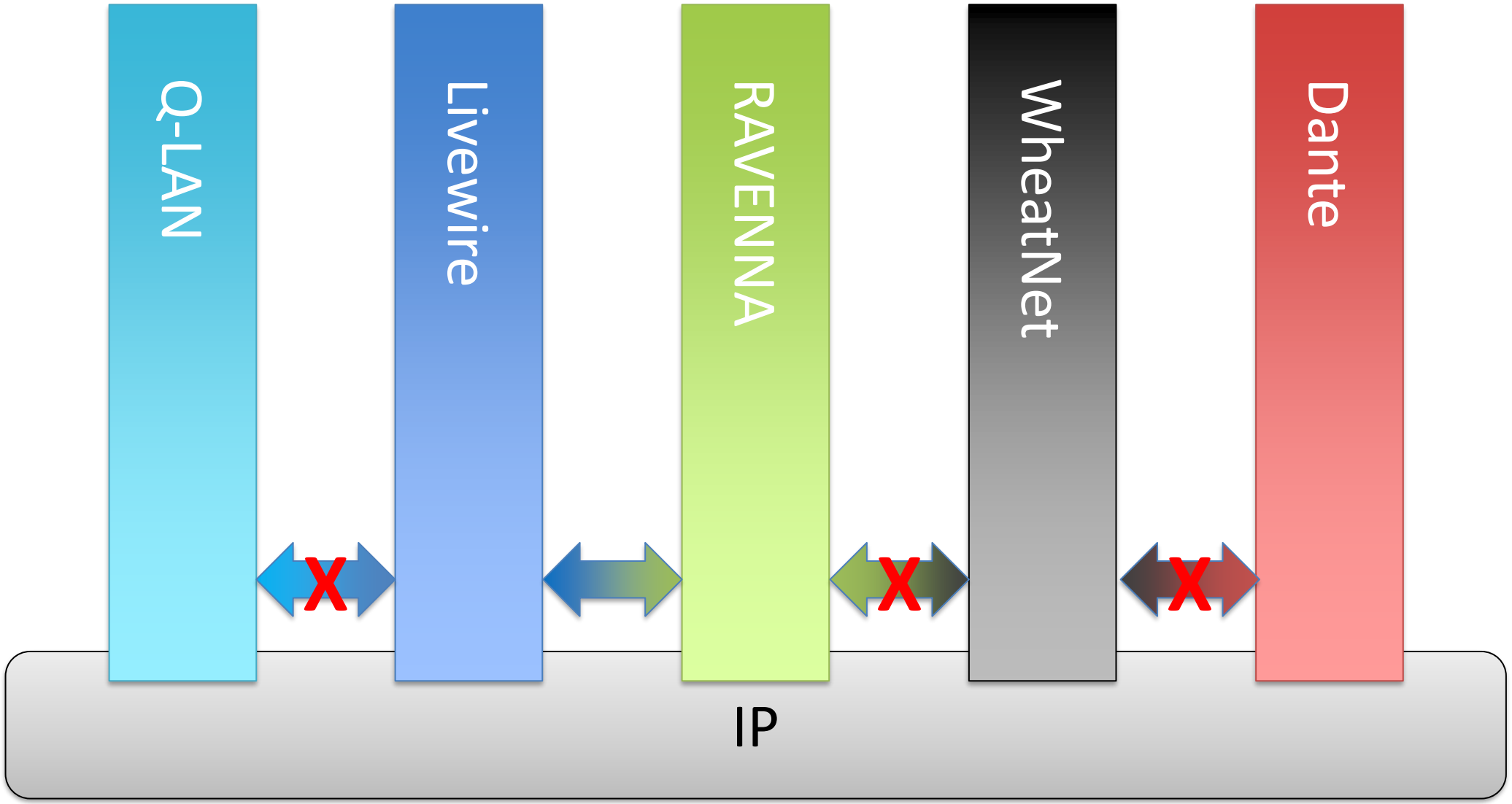
AES67

AES67-2018 Standard for Audio Applications of Networks:

High-performance Streaming Audio-over-IP Interoperability

Initial publication on September, 11th, 2013

AES67 - High-performance Streaming Audio-over-IP Interoperability



AES67 - High-performance Streaming Audio-over-IP Interoperability

CELEBRATING 10 YEARS RAVENNA AES67 & ST 2110 built-in

AES67 technology components

Discovery	Not specified (NMOS IS-04/05)
Connection Management	SIP (unicast), IGMP (multicast)
Session Description	SDP (RFC4566, RFC7273)
Encoding	L16/L24, 1..8 ch, 48 samples
QoS	Differentiated Services (DiffServ w/ 3 CoS)
Transport	RTP / UDP / IP, unicast & multicast
Media Clock	48 kHz
Synchronisation	IEEE 1588-2008 (PTPv2)

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AUDIO
ES
AES67
RAVENNA

AES67 - High-performance Streaming Audio-over-IP Interoperability

AES67	RAVENNA
	+ Discovery
	+ Redundancy
QoS three classes	+ classes adjustable
Media Format L16/L24 PCM	+ AES/EBU, DSD/DXD, Video
48 Samples per packet	+ 1, 6, 12, 64…
1-8 Audio channels	+ 64, 128…
Encoding 48kHz	+ 44.1, 96, 192, 384kHz…

AES67 - High-performance Streaming Audio-over-IP Interoperability

RAVENNA AES67 built-in	+ Discovery
	+ Redundancy
QoS three classes	+ classes adjustable
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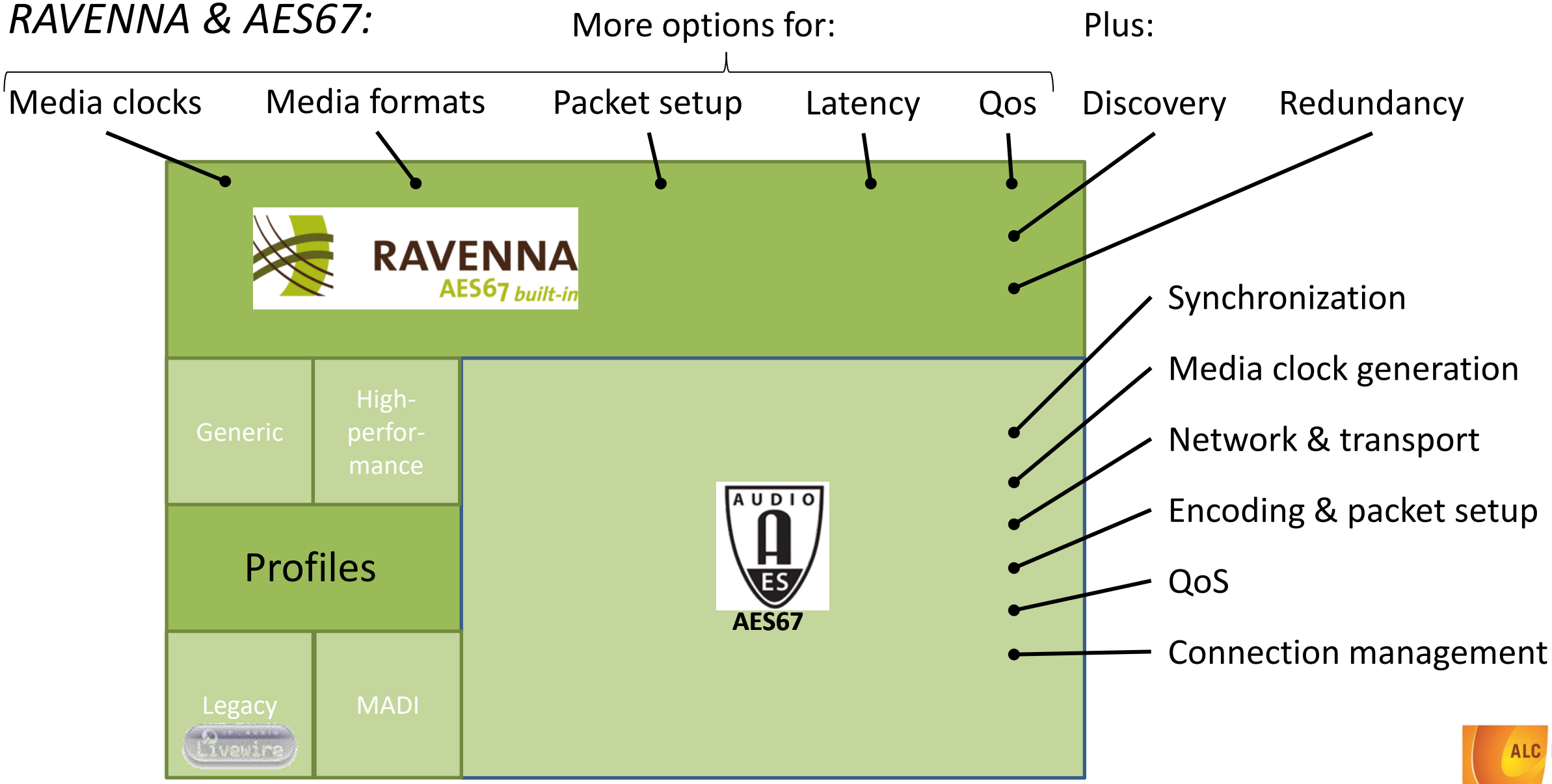
AES67

More Features

More Options


RAVENNA & AES67:
More options for:
Plus:
Media clocks
Media formats
Packet setup
Latency
Qos
Discovery
Redundancy
RAVENNA
AES67 built-in
Generic
High-perfor-mance
Profiles
Legacy
Livewire
MADI
AUDIO
ES
AES67
Synchronization
Media clock generation
Network & transport
Encoding & packet setup
QoS
Connection management

SMPTE ST 2110 – Professional Media over Managed IP Networks

The SMPTE ST 2110 standards suite specifies

- the transport, synchronization and description of
  - separate elementary essence streams (video, audio, ancillary data)
    - over managed IP networks (at any speed, from 1GbE to 100 GbE and beyond)
      - for real-time production, playout and other professional media applications

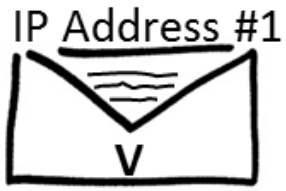
CELEBRATING 10 YEARS RAVENNA AES67 & ST 2110 built-in

SMPTE ST 2110 – The essence-based approach

Active Video

IP Packetization of Active Video

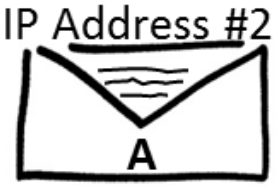
Method: **SMPTE ST 2110-20**



Audio

IP Packetization of Audio Channels

Method: **SMPTE ST 2110-30**



Metadata

IP Packetization of ANC Data

Method: **SMPTE ST 2110-40**

Published in 2017

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SMPTE ST 2110 - Professional Media over Managed IP Networks

Document structure (audio):

- 2110-**10**: System Timing & Definitions
  - defines transport layer and synchronization (SMPTE2059, clocks, RTP, SDP etc.)
- 2110-**30**: PCM Digital Audio
  - defines payload format for linear audio (AES67, constraints)
- 2110-**31**: AES3 Transparent Transport
  - defines payload format for non-linear audio (RAVENNA AM824)

CELEBRATING 10 YEARS RAVENNA AES67 & ST 2110 built-in

SMPTE ST 2110 - Professional Media over Managed IP Networks

Document structure (linear PCM audio):

- 2110-**10**: System Timing & Definitions
  - defines transport layer and synchronization (SMPTE2059, clocks, RTP, SDP etc.)
- 2110-**30**: PCM Digital Audio
  - defines payload format for linear audio (AES67, constraints)

AES67 Constraints!

⇨ AIMS WP on
AES67 / ST2110 Commonalities & Constraints

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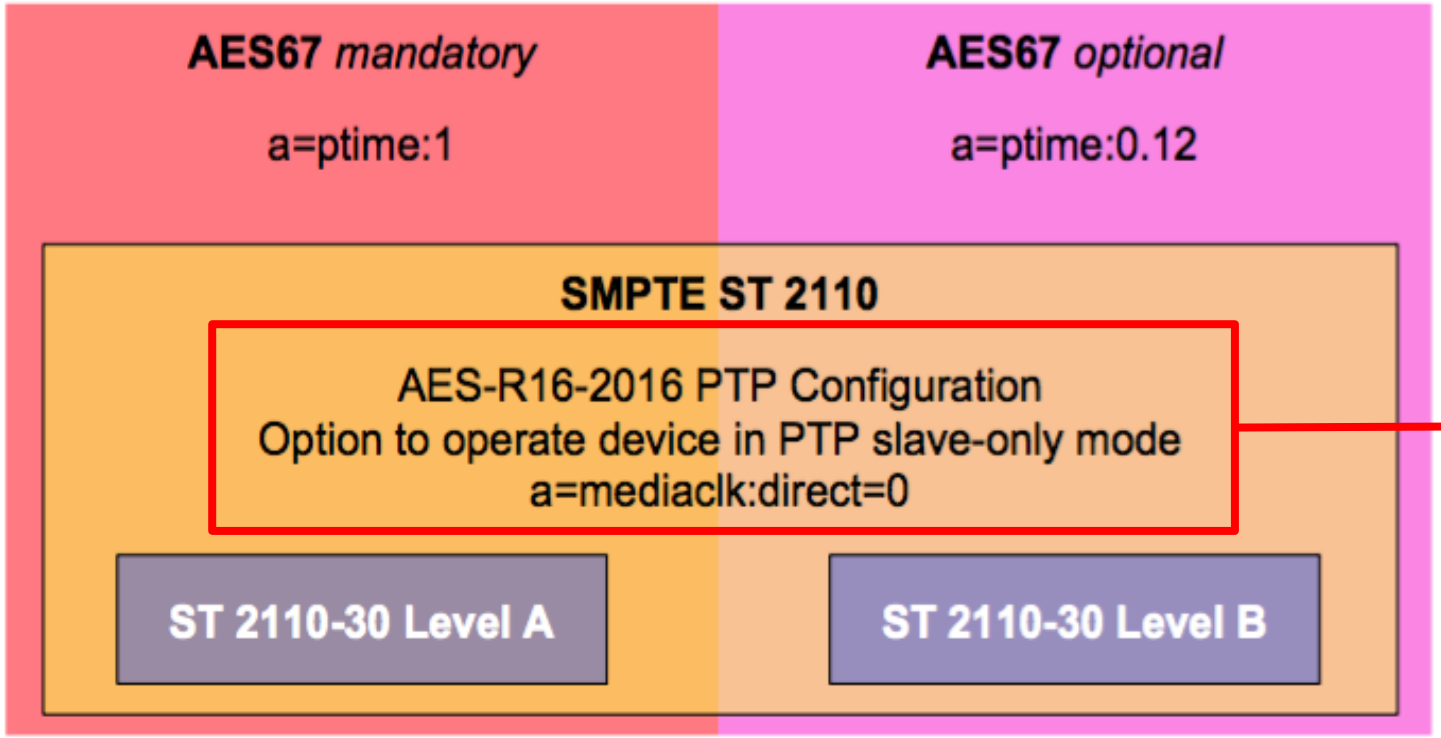
SMPTE ST 2110 - Professional Media over Managed IP Networks

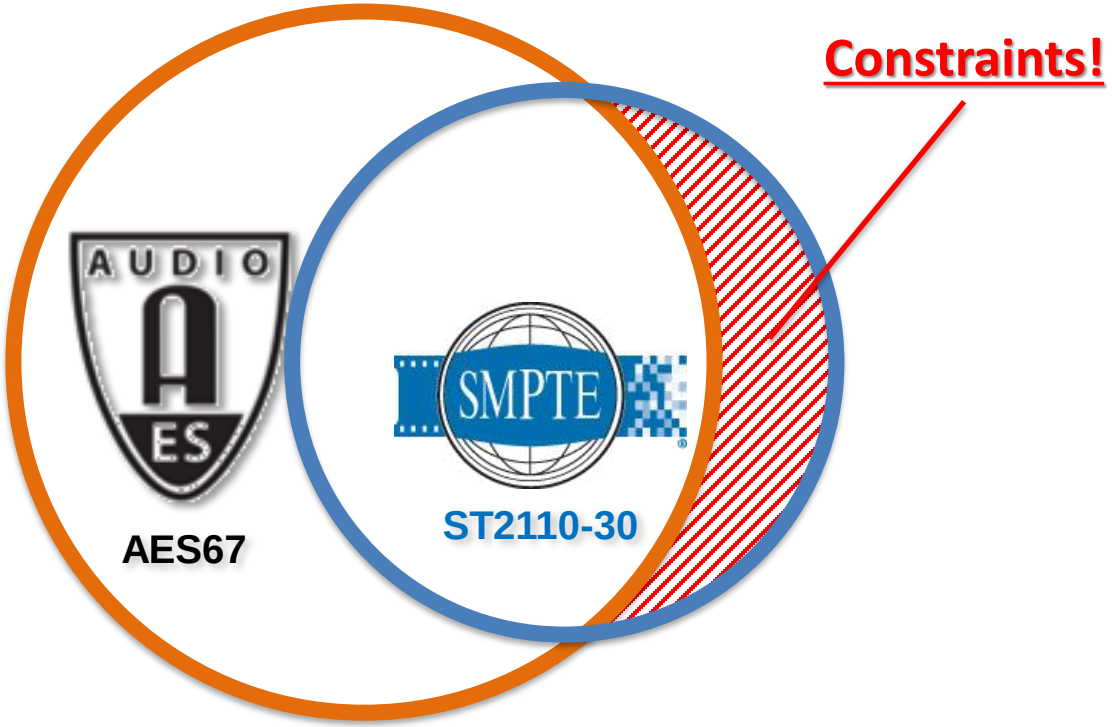
SMPTE ST 2110-30 is a subset of AES67,
adding constraints to clocking and streaming



Constraints!

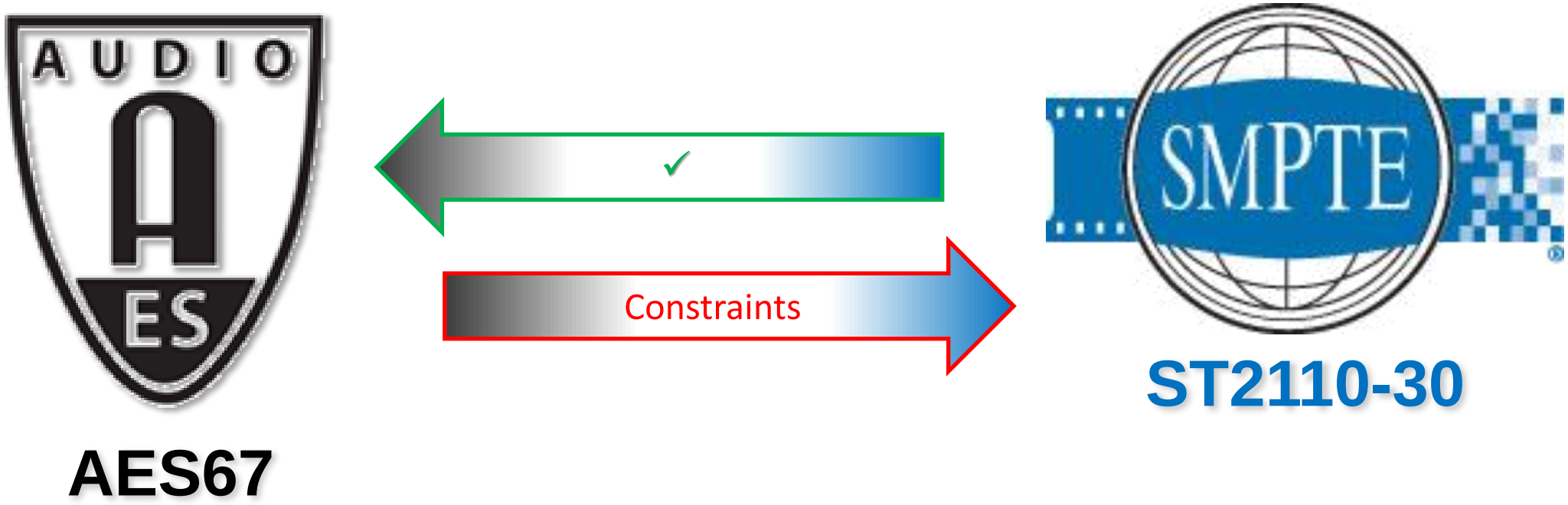
SMPTE ST 2110 - Professional Media over Managed IP Networks

AES67 / ST 2110-30 compatibility?



SMPTE ST 2110 - Professional Media over Managed IP Networks

AES67 / ST 2110-30 stream compatibility?



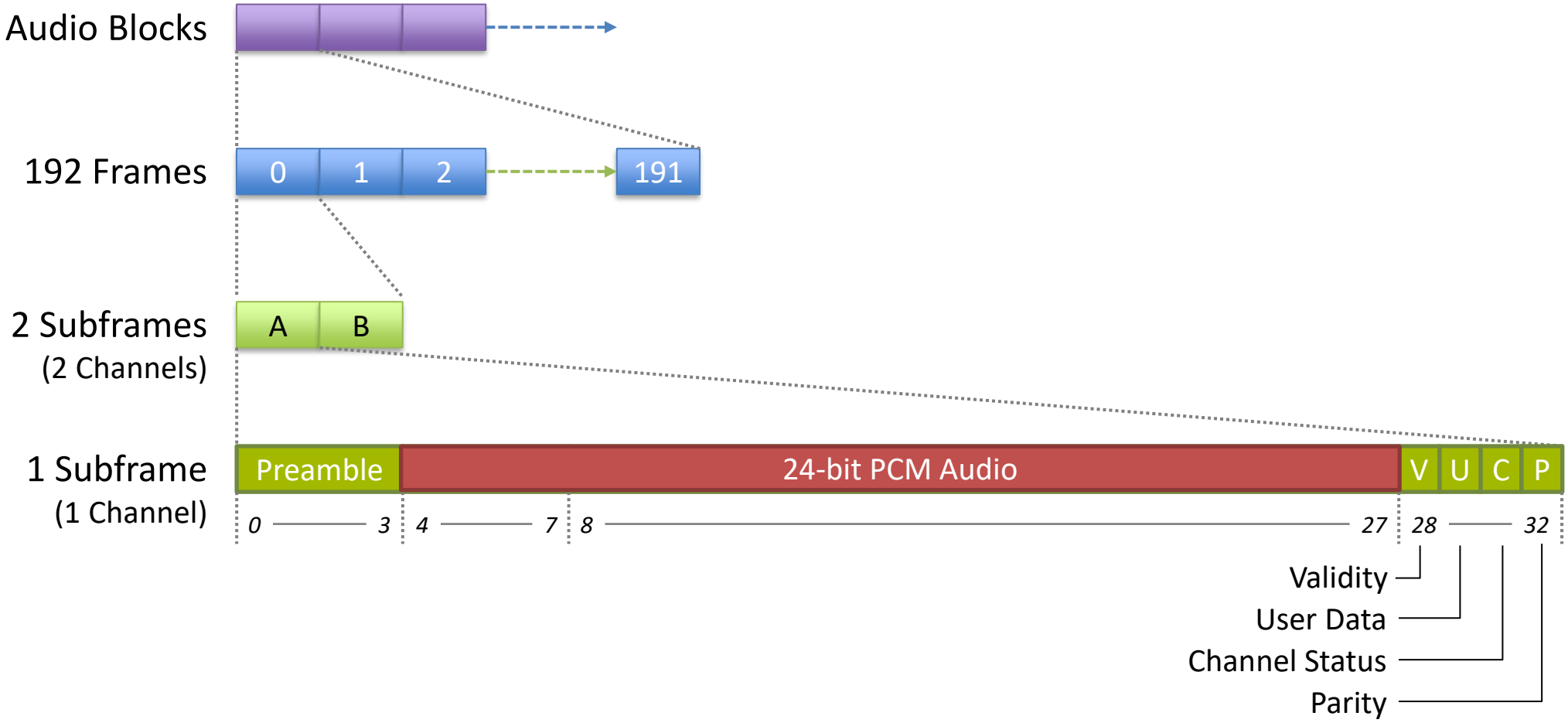
SMPTE ST 2110 - Professional Media over Managed IP Networks

ST 2110-31 – transparent transport of AES3 audio data

- Can transport any format which can be encapsulated in AES3
  - L24 PCM w/ AES3 subframe meta data (PCUV bits)

SMPTE ST 2110 - Professional Media over Managed IP Networks

AES3 data structure



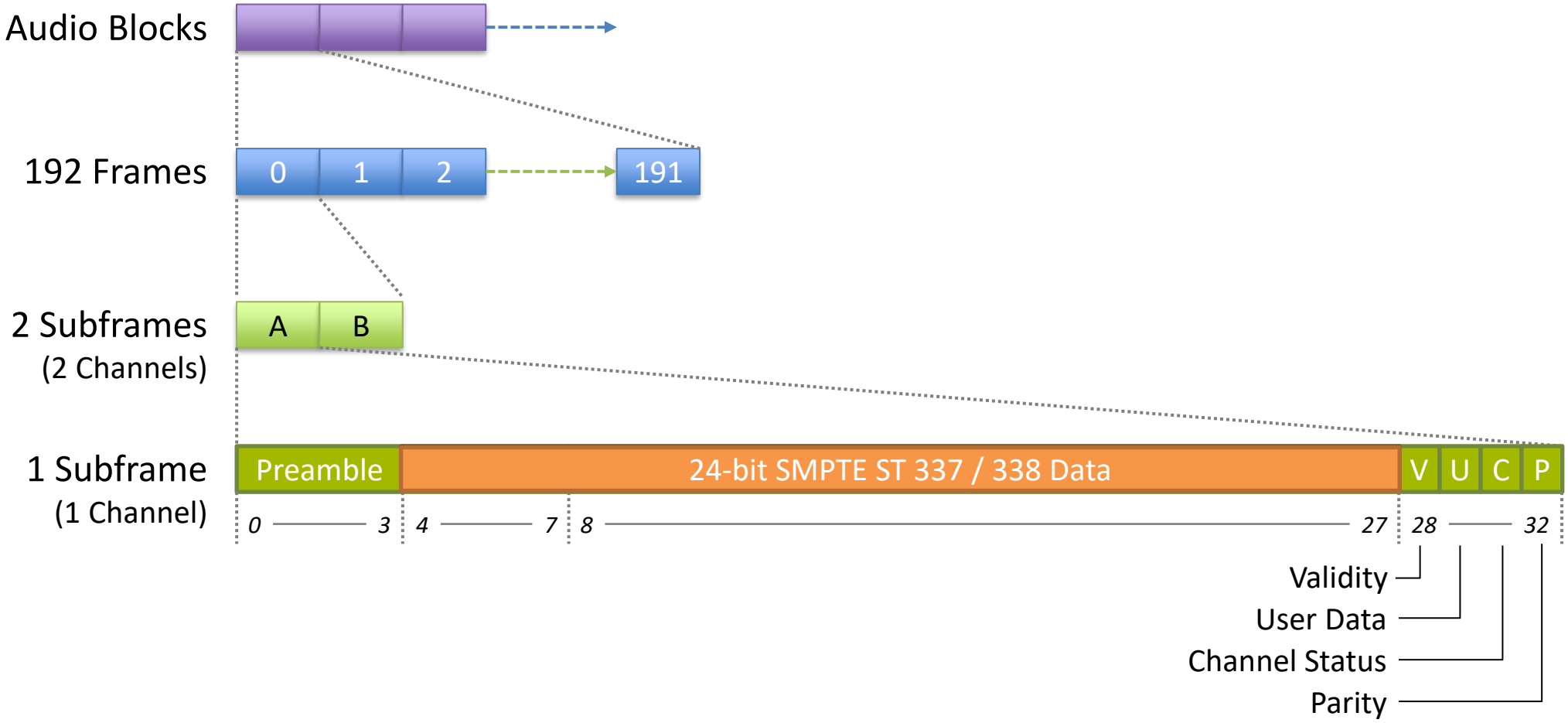
SMPTE ST 2110 - Professional Media over Managed IP Networks

ST 2110-31 – transparent transport of AES3 audio data

- Can transport any format which can be encapsulated in AES3
  - L24 PCM w/ AES3 subframe meta data (PCUV bits)
  - non-PCM audio and data formats as defined by SMPTE ST 337 / 338 (i.e. Dolby®E etc.)

SMPTE ST 2110 - Professional Media over Managed IP Networks

AES3 data structure



SMPTE ST 2110 - Professional Media over Managed IP Networks

ST 2110-31 – transparent transport of AES3 audio data

- Builds on RAVENNA's AM824 (IEC 61883-6) payload definition:
  - retains AES67 definitions for synchronization and RTP usage
  - uses 3 bytes for PCM24 + 1 byte for AES3 meta data

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|0|B|F|  PCUV |                  DATA24                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

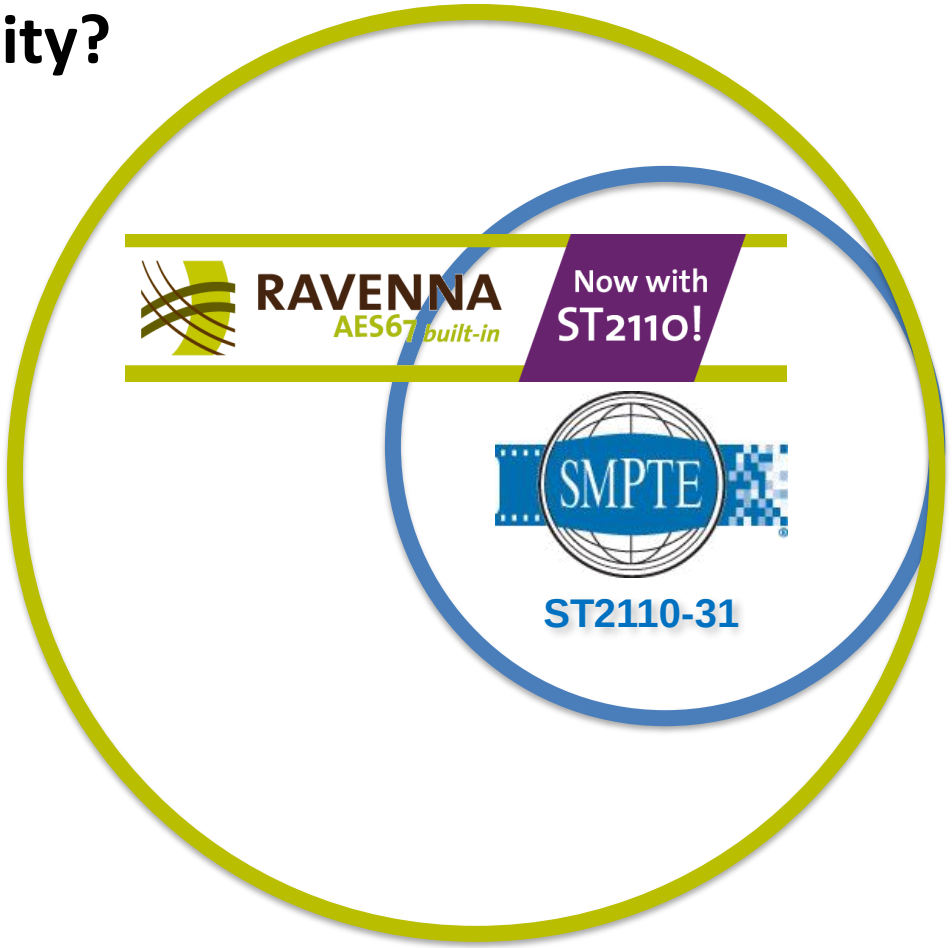
  - RTP payload format signaled in SDP:

    `a=rtpmap:<pt> AM824/48000/<nchan>` - with `<nchan>` always being an equal number (stereo channels)

  - retains all other SDP parms

SMPTE ST 2110 - Professional Media over Managed IP Networks

AES67 / ST 2110-31 compatibility?



SMPTE ST 2110 - Professional Media over Managed IP Networks

AES67 / ST 2110-31 stream compatibility?

RAVENNA
AES67 & ST 2110 built-in

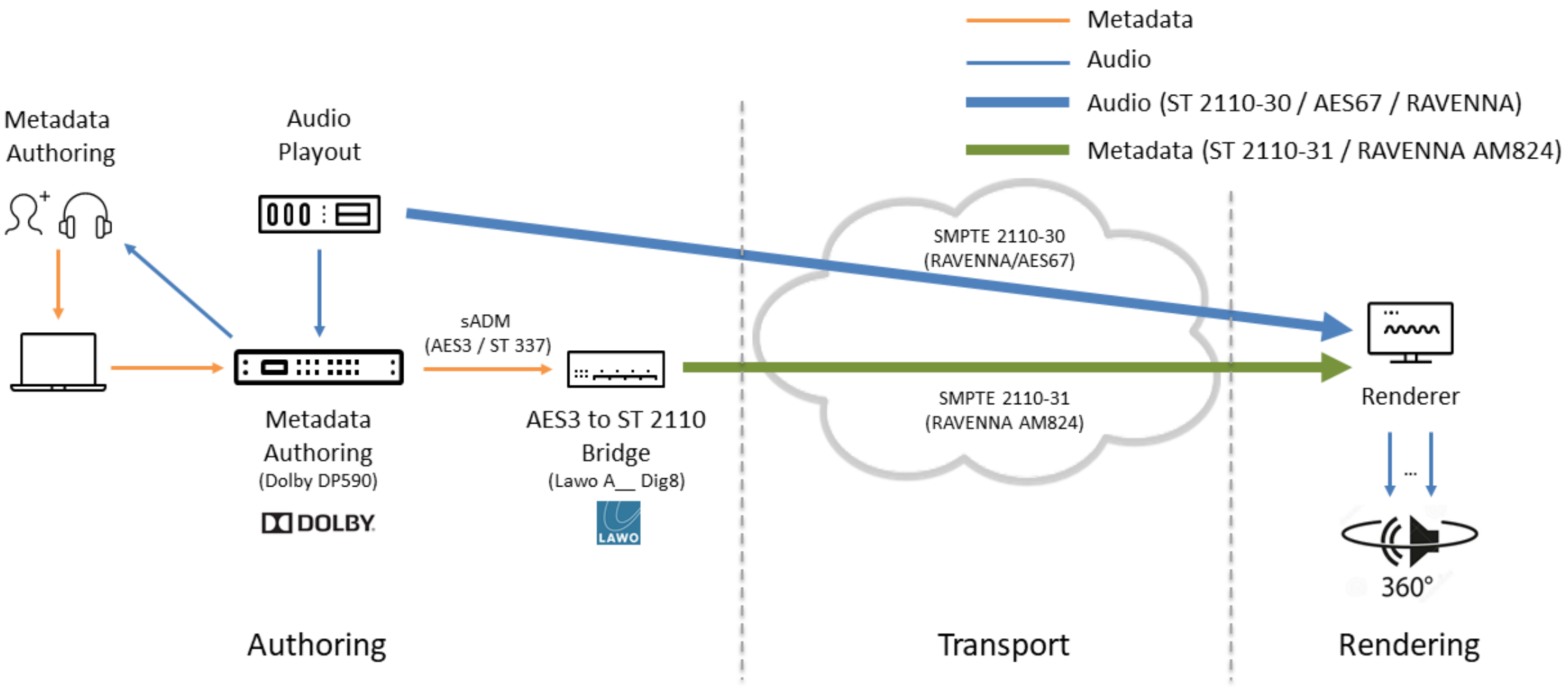
[ST 2110 / AM824 profile] →

← [add'l requirements (discovery)]

SMPTE

ST2110-31

SMPTE ST 2110 - The Audio Parts



SMPTE ST 2110-31 Applications

James Cowdery

DOLBY

SMPTE ST 2110-31 Applications

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DOLBY E AND PROFESSIONAL METADATA

JAMES COWDERY

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Agenda

Review of SMPTE ST 337

- PCM and SMPTE ST 337 switching
- Channel status bit use-cases in live broadcast - specifically audio bit

Introduction to Dolby E in SMPTE ST 337/SDI, switching requirements

- Timing constraints of Dolby E and requirements when converting to/from SDI
- Packetization of Dolby E in Ravenna AM824/ST 2110-31 to enable packet-level switching

Introduction to Metadata for next-generation audio production

- Serial ADM and PMD formats over SMPTE 2110-31
- SMPTE 2110-41 Fast Metadata project

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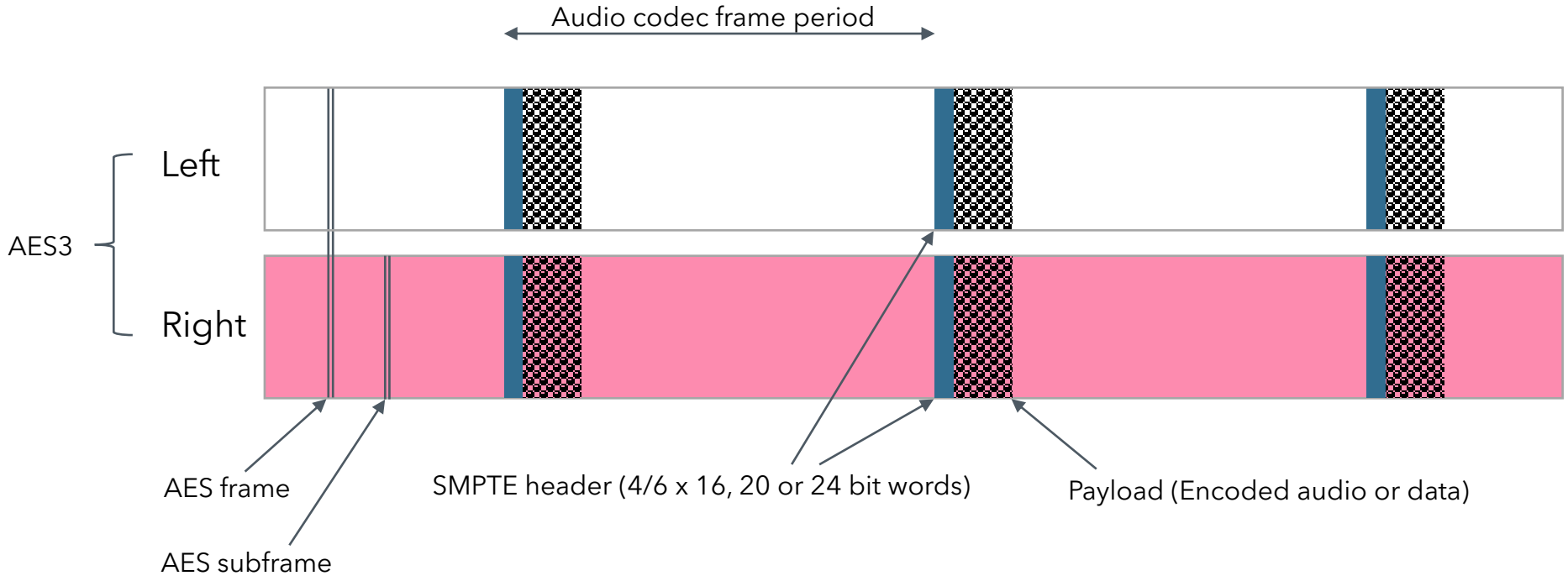
What is SMPTE ST 337?

- Method for carrying non-PCM encoded audio or data over AES3 transport.



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SMPTE ST 337 Data-types – Defined in ST 338

0	Null Data	7	MPEG2 LC/HE-AAC	27	KLV (ST 336)
1	Dolby Digital (AC-3)	10	MPEG-4 LC-AAC	28	Dolby E
2	Time-Stamps (ST 339)	11	MPEG-4 HE-AAC	29	Captions (ST 341)
3	Pause Data	16	Dolby Digital Plus (E-AC-3)	30	User defined (ST 339)
4	MPEG-1 Layer 1	17	DTS	31	Extended data-type
5	MPEG-1 Layer 2/3 w	24	Dolby AC-4		
6	MPEG-1 Layer 2/3 w ext.	26	Utility data type (V sync)		

- Serial ADM metadata carried using extended data-type 0x0001(2019 Addendum)

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AES3 Channel Status Bits

- Not carried by AES67 / SMPTE 2110-30, only SMPTE 2110-31

Example fields	Values			
Use of channel status block	Professional		Consumer	
Audio Signal Emphasis	None	50µs+15µs	ITU-T J.17	Not indicated
Sampling Frequency	32 kHz	44.1 kHz	48 kHz	Not indicated
Linear PCM identification	Linear PCM		Not Linear PCM	

- Required for dynamic switching between Linear PCM and Not Linear PCM
- Therefore Ravenna AM824 / SMPTE ST 2110-31 must be used to carry Dolby E
- One set of channel status bits per AES subframe/mono audio track

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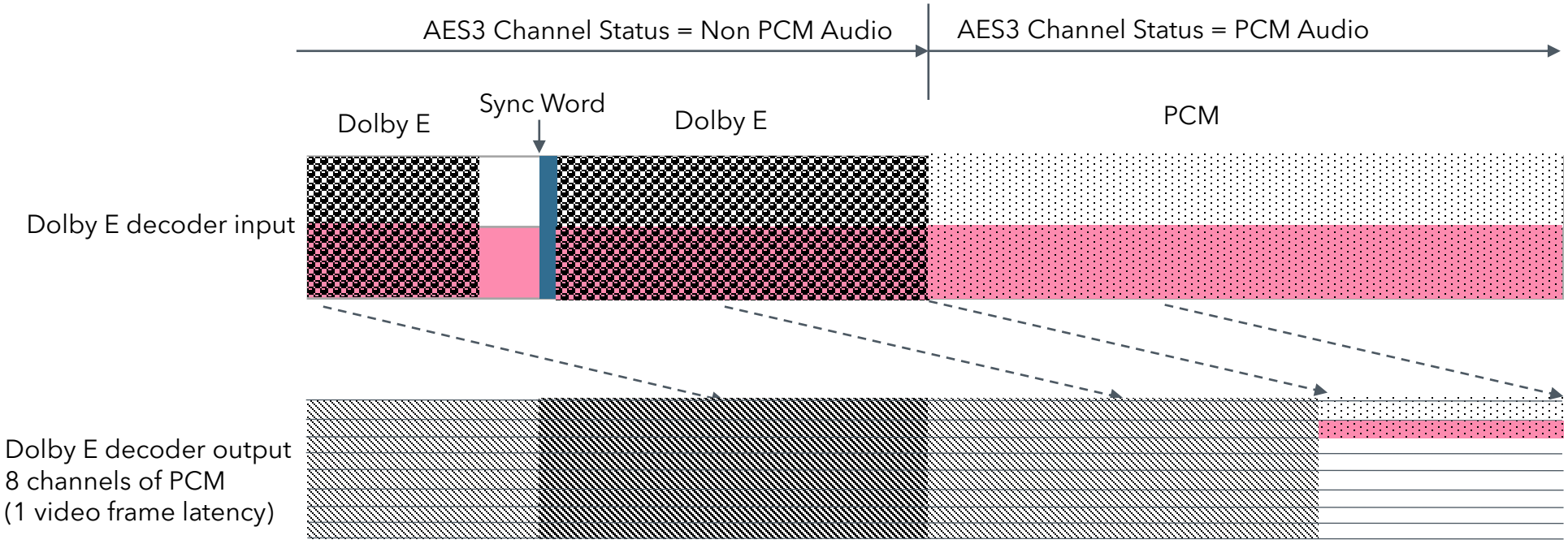
Channel Status Use with Dolby E



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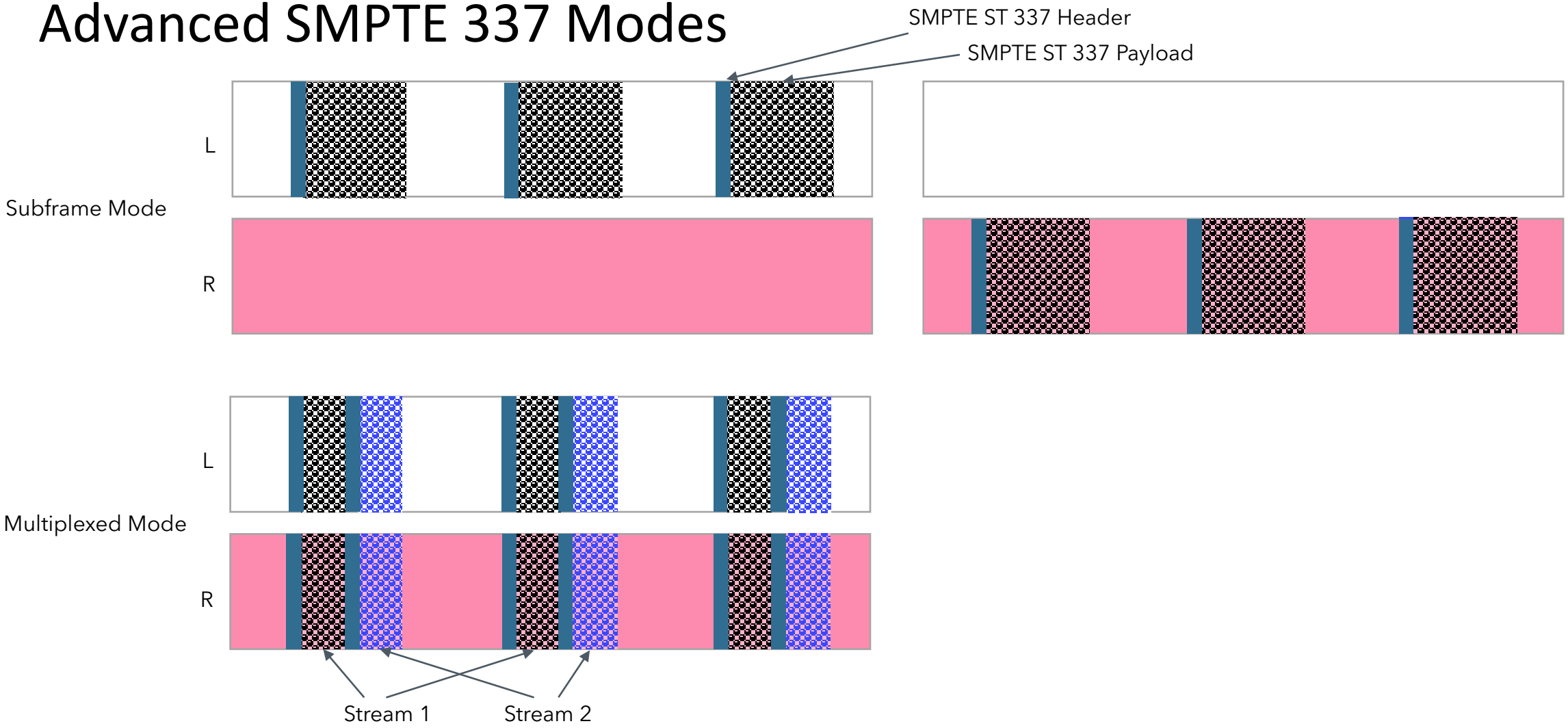
Advanced SMPTE 337 Modes



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Review of Dolby E

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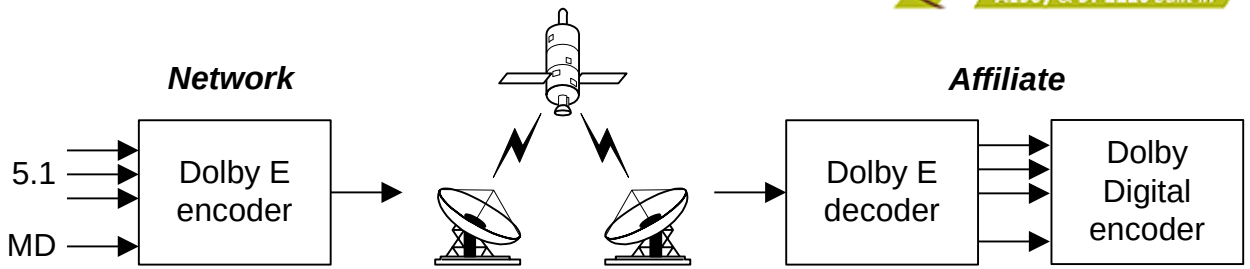
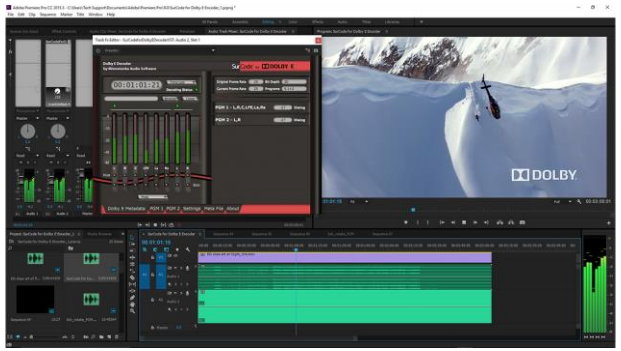
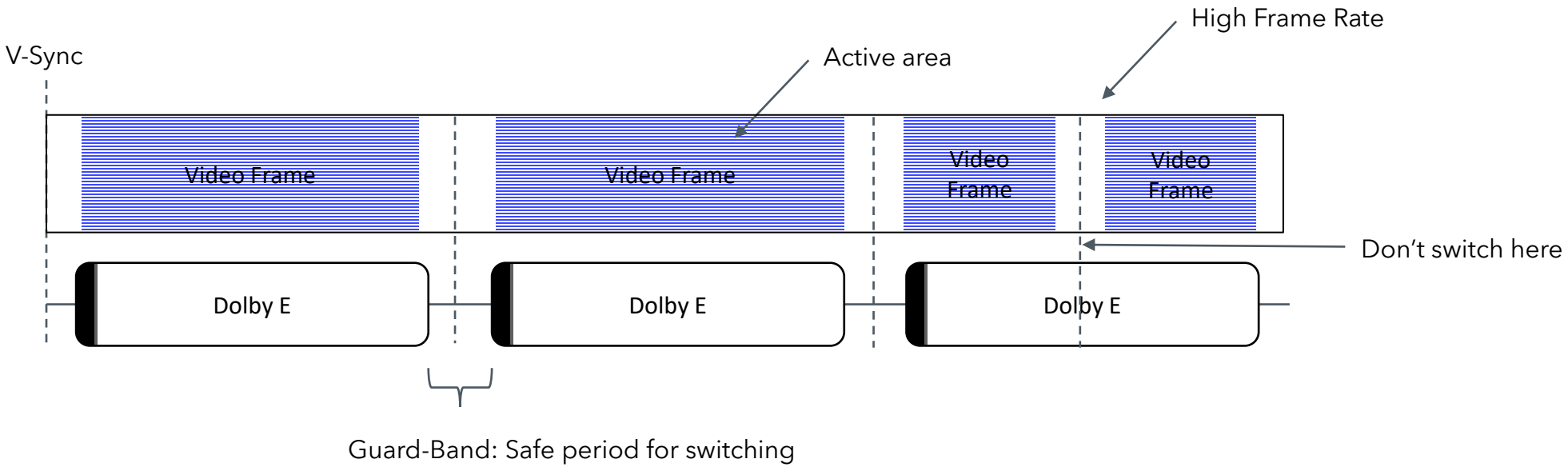
What is Dolby E?



- Introduced in 1999 as professional broadcast distribution codec
- Provides 4:1 compression - stereo pair carries 8 mono tracks
- High quality supports multiple re-encodes
- Video frame Synchronization – supports switching and editing
  - Low frame rates only
- Integration with Dolby Digital (Plus) by providing metadata
- Multi-program support (5.1 + stereo over single AES3)
- Seamless cross-fades
- Single video frame encoder/decoder latency
- Can be carried over MPEG-2 Transport Stream via SMPTE 302



Dolby E timing and line position



- Timing of guard-band varies with resolution and frame-rate
- General timing specification for switching is defined in SMPTE RP-168
- For Dolby E line position specification see SMPTE RDD-33

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Dolby E Resources

SMPTE specification: SMPTE RDD33

Reference Docs: https://developer.dolby.com/dolby-professional/professional-technologies/dolby-e/

- High level bitstream specification
- Technical Requirements for Third-Party Product Compatibility with Dolby E Bitstreams
- Frame Synchronizers – Technical Bulletin
- Realigning and Synchonizing Dolby E Streams with Video
- Manufacturer Guidelines: Handling of Dolby E in Environments Using Progressive Frame Rates

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Dolby E Line Positions

Table 4-2 Dolby E Reference Line Position

Video Format	Dolby E Frame Rate (fps)	Total Number of Lines	Earliest Valid Position		Ideal Position						Latest Valid Position	
					-80uS		±80uS		+80uS			
			Line	µS	Line	µS	Line	µS	Line	µS	Line	µS
625/50/i	25	625	8	450	11	650	12	730	13	810	30	1860
525/59.94/i	29.97	525	12	510	13	610	14	690	16	770	26	1400
Dolby Black/23.98	23.98	693	10	390	18	890	20	970	21	1050	63	3610
Dolby Black/24	24	625	9	390	17	890	18	970	19	1050	58	3610
Dolby Black/30	30	500	11	510	13	610	14	690	15	770	26	1530
1920x1080/60/i	30	1125	18	510	21	610	24	690	26	770	52	1530
1920x1080/59.94/i	29.97	1125	18	510	21	610	24	690	26	770	48	1400
1920x1080/50/i	25	1125	13	450	19	650	21	730	23	810	53	1860
1920x1080/48/i	24	1125	11	390	25	890	27	970	29	1050	98	3610
1920x1080/47.97/i	23.98	1125	11	390	25	890	27	970	29	1050	98	3610
1920x1080/60/p	30	1125	35	510	42	610	47	690	52	770	104	1530
1920x1080/59.94/p	29.97	1125	35	510	42	610	47	690	52	770	95	1400
1920x1080/50/p	25	1125	26	450	37	650	42	730	46	810	105	1860
1920x1080/30/p	30	1125	18	510	21	610	24	690	26	770	52	1530
1920x1080/29.97/p	29.97	1125	18	510	21	610	24	690	26	770	48	1400
1920x1080/25/p	25	1125	13	450	19	650	21	730	23	810	53	1860
1920x1080/24/p	24	1125	11	390	25	890	27	970	29	1050	98	3610
1920x1080/23.98/p	23.98	1125	11	390	25	890	27	970	29	1050	98	3610
1280x720/60/p	30	750	23	510	28	610	32	690	35	770	69	1530
1280x720/59.94/p	29.97	750	23	510	28	610	32	690	35	770	63	1400
1280x720/50/p	25	750	17	450	25	650	28	730	31	810	70	1860
1280x720/30/p	30	750	12	510	14	610	16	690	18	770	35	1530
1280x720/29.97/p	29.97	750	12	510	14	610	16	690	18	770	32	1400
1280x720/25/p	25	750	9	450	13	650	14	730	16	810	35	1860
1280x720/24/p	24	750	8	390	17	890	18	970	19	1050	65	3610
1280x720/23.98/p	23.98	750	8	390	17	890	18	970	19	1050	65	3610

µS = Microseconds

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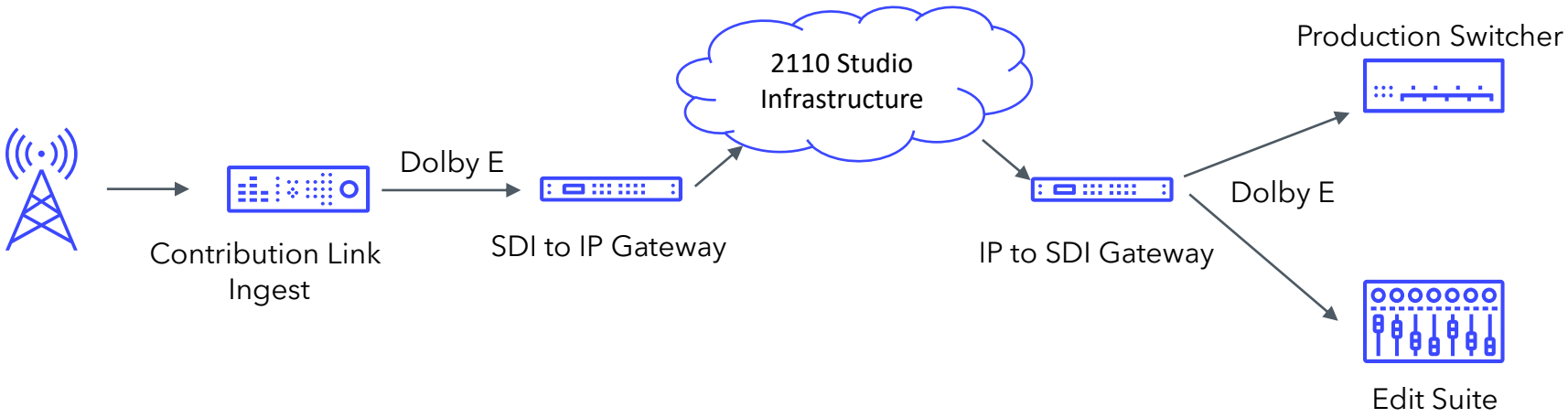
Dolby E over ST 2110-31 Use-Case



- Use-case is possible during IP transition (use of legacy SDI equipment)
- Down-stream switching is possible so valid line-position must be maintained
- Desire to test line-position both in SDI and IP domains

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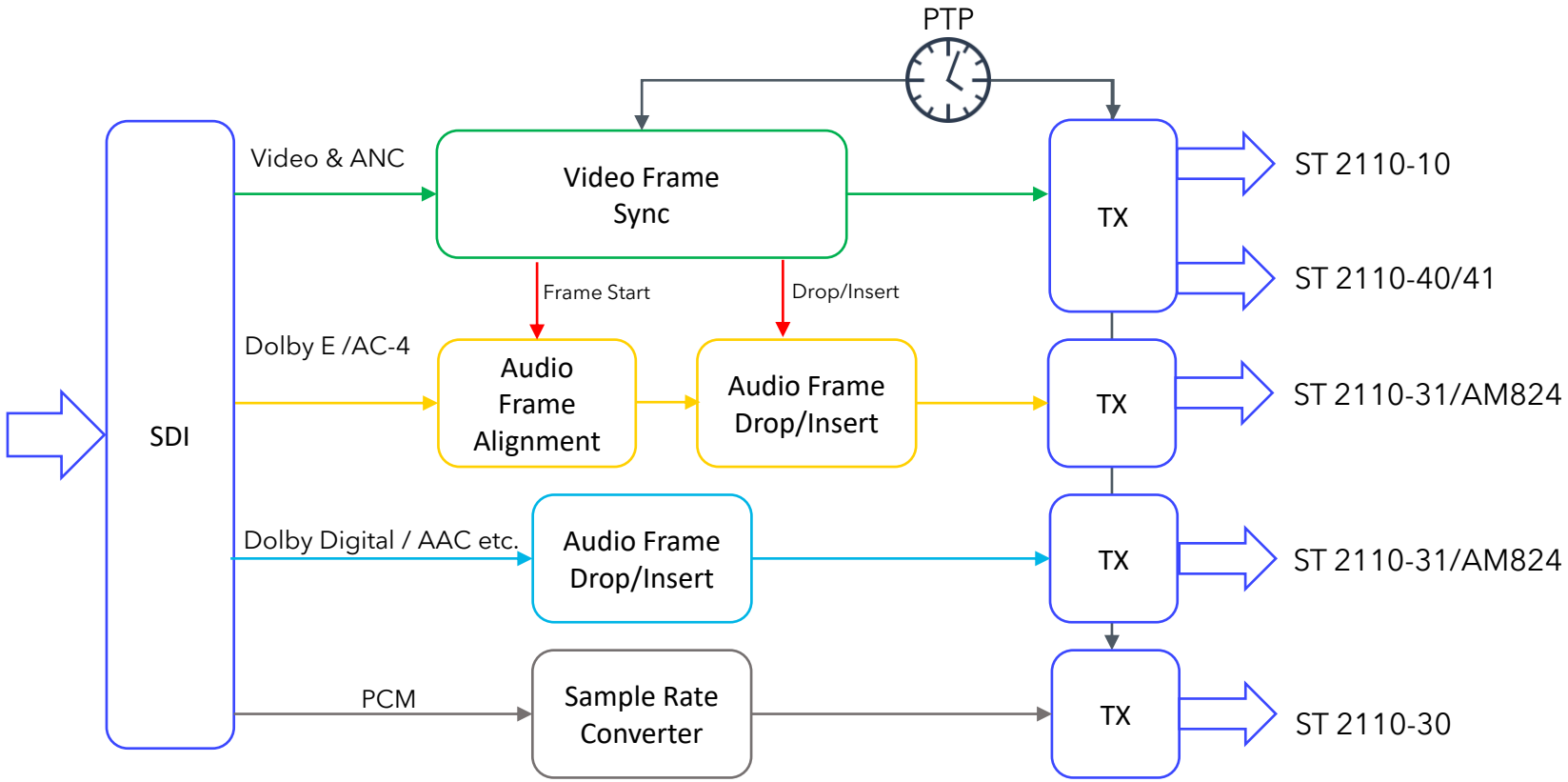
SDI to IP Gateway Design

Asynchronous Input:
- Video
- Up to 16 channels of PCM audio / Dolby E, Dolby Digital Dolby AC-4 or AAC etc.



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Dolby E in IP alignment guidance

- A/V sync support in IP gateways using Ravenna AM824 / SMPTE 2110-31 preserves line-position
  - Dolby E working over IP today without Dolby support or guidance
- Audio-only IP gateways will not maintain current line-position
  - End-to-end audio delay must be integer number of 25/29.97 fps video frames
  - Manual configuration will not work with fractional frame-rates e.g. 29.97 fps
- Packet level switching of Dolby E is possible but requires 125μs packet time
  - Audio stream switcher must be aware of guard band

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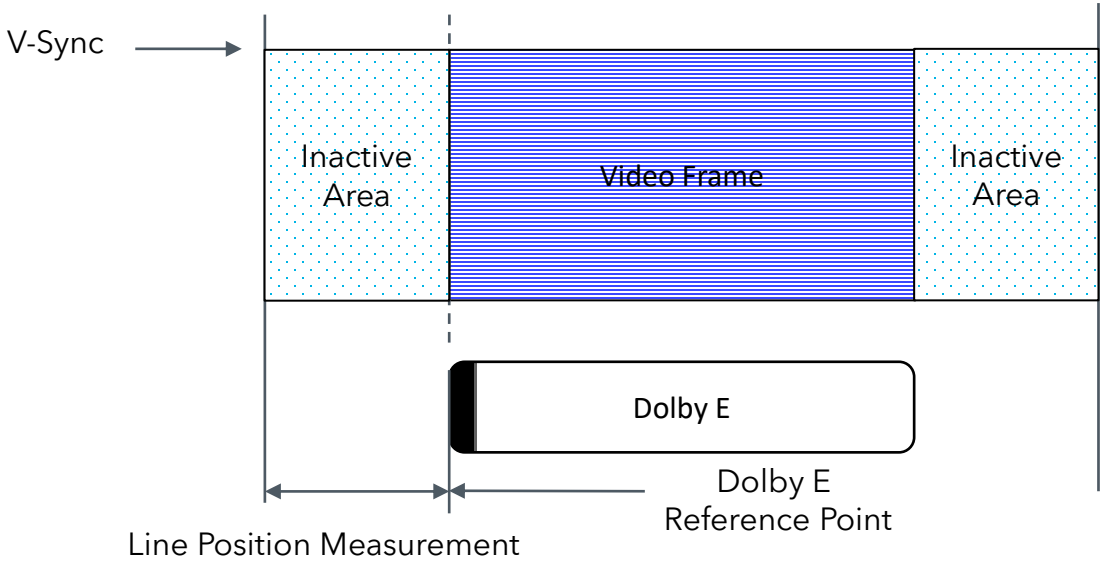
Dolby E in IP alignment testing

- IP-based line position testing can be performed today using legacy test and measurement equipment and a reference IP to SDI gateway
- Native IP-based line position testing is under development in at least one product by a reference test and measurement manufacturer



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Professional Metadata for Next Generation Audio

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Solutions for NGA Professional Metadata

File Interchange	Archiving	Live Broadcast	Post Production
IMF with ST 2098 IAB plug-in	Audio Definition Model (ADM) ITU-R BS 2076	PCM with PMD (RDD49) or Serial ADM (ITU-R BS 2125)	ADM ITU-R BS 2076 or IMF with ST 2098 IAB plug-in

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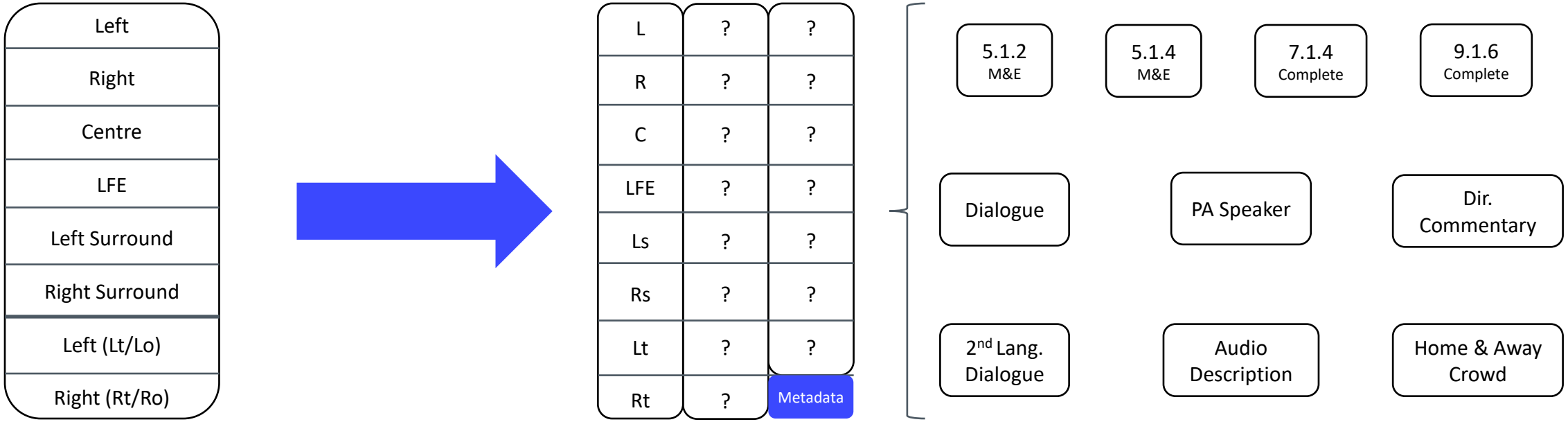
Why do we need it?

SDI Line-Up



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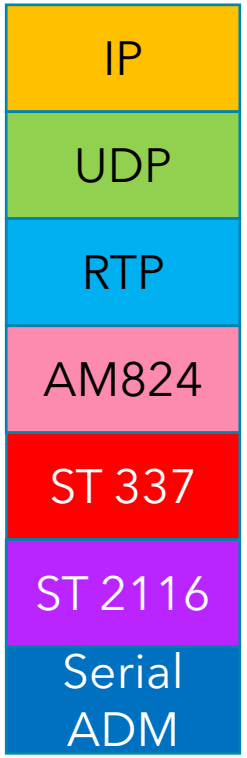
Serial ADM - Serialized XML from Audio Definition Model

- Approach
  - Translates metadata directly from/to ITU-R BS 2076 Audio Definition Model (Broadcast Wave + XML)
  - Packs XML from ADM into a frame-based structure with GZip compression option – defined in ITU-R BS 2125
  - Provides some packing option to limit data-rate – affects switching capability
- Features
  - Fully compatible with the structure, attributes and elements of ADM
  - Independent of transport or interface method
  - Handles any combination of channel-, object-, and scene-based audio programs as described by ITU-R BS 2076
  - No restriction on frame size
  - Allows for random-access support
  - Can be carried over multiple pairs of AES3 via SMPTE ST 2116 so compatible with SMPTE 2110-31 / Ravenna AM824



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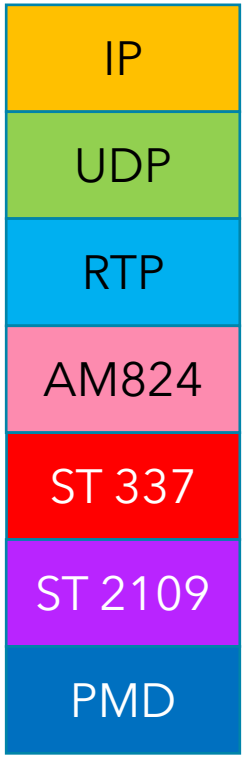
PMD - Binary Payload Model

- Approach
  - Frame-based binary payload based around ADM structure
  - KLV (SMPTE ST 336) container for carriage over RTP and use in file-based formats
  - Fully extensible structure allowing support for all NGA emission formats
    - SMPTE Metadata Dictionaries (ULs) for payload identification
  - Binary payload structure published as SMPTE RDD 49
    - Documents current implementation with goal to migrate to standard payloads in future
  - Patent-free, license-free - open source reader/writer code on GitHub (https://github.com/DolbyLaboratories/pmd_tool)
- Features
  - Can be carried over AES3 pair using SMPTE ST 2109 so compatible with SMPTE 2110-31 and Ravenna AM824
  - Supports all known country and regional use-cases e.g. ATSC 3.0, DVB, Nordig, UltraHD Forum Italia
  - Very low data-rate and low latency enables video frame level switching including high-frame rates in legacy systems



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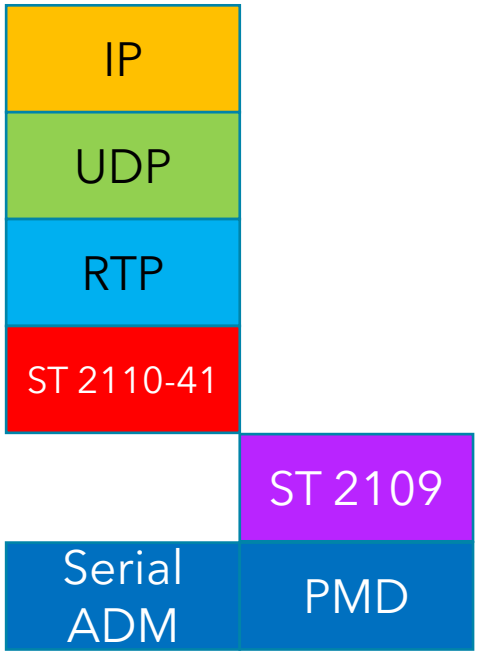
Future Non-ST 2110-31 based metadata over IP

- Metadata carried natively over RTP. No tunneling or legacy transport compatibility.
- More data-rate efficient than AM824/ST 2110-31 based solutions
- SMPTE ST 2110-41 Fast Metadata project in draft status
- AES-X242 project, despite predating -41 is now aligning with it



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Thank You

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Questions?

Answers!

RAVENNA / AES67 / SMPTE ST 2110 Resources:

RAVENNA
AES67 & ST 2110 built-in

www.ravenna-network.com/resources

You've made it!

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