

Pipes are now Packets: What you really need to know about QC monitoring & maintenance for IP

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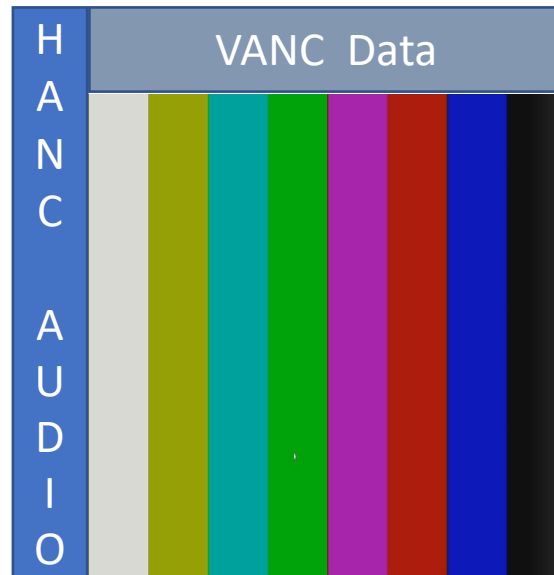
IP SHOWCASE

- Just remember that IP is just another I/O interface: A way to get video, audio and data to or from a switch
- It's **how** you do that , that has changed.

- Although many broadcasters are transitioning to IP, the majority are going to do so in a piecemeal manner.
- With ST-2110, the timing information has been removed from the underlying hardware layer making the distribution asynchronous.
- With current broadcast formats, video must be frame synchronous at the camera's sensor and at the viewers display device.
- The intermediate IP distribution network is asynchronous but the variance in packet jitter directly affects latency leading to potentially longer video and audio delays than we have come to expect from SDI infrastructures.
- Although uncompressed video such as that provided by ST-2110 does map to the active video parts of SDI, two major changes have occurred;
 - The PTP and SPG reference sources may or may not be the same device
 - Signal distribution in IP is asynchronous and multiplexed.

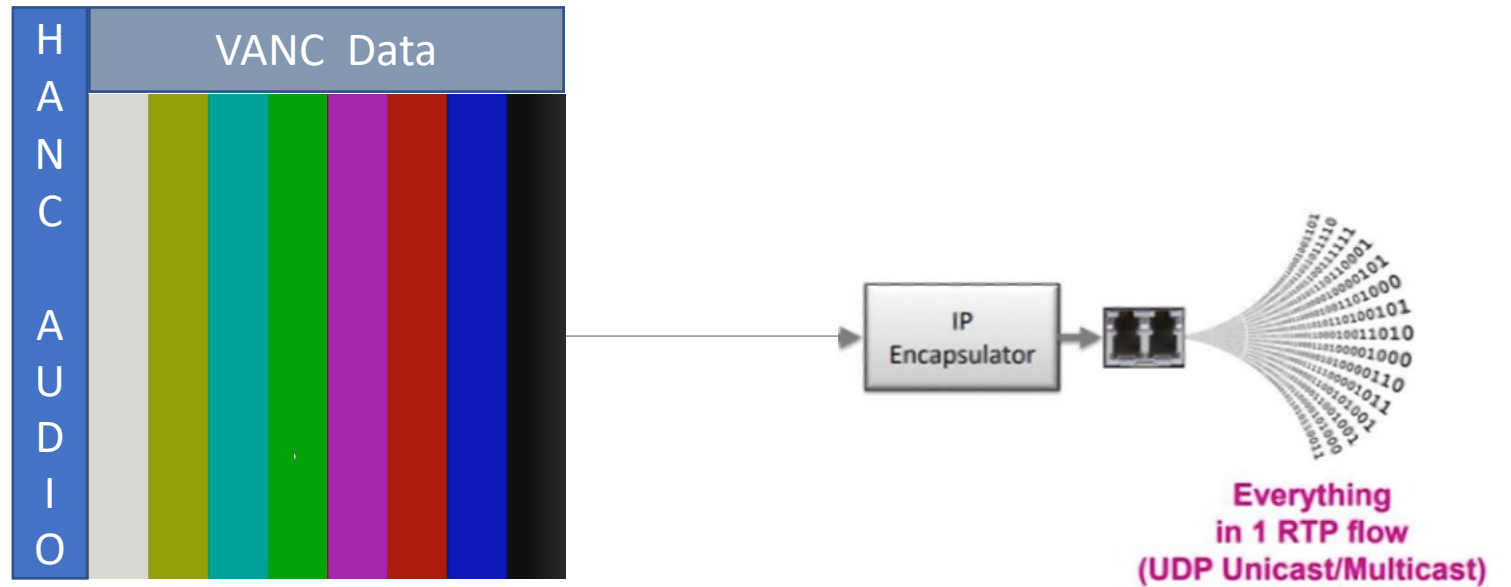
SDI Transmission

- In SDI we send Video, Audio and Data all on the same coaxial cable, line by line.
- We send a Field or Frame of Video, the Audio that goes with each Field or Frame and the ANC data that goes with that Field or Frame.



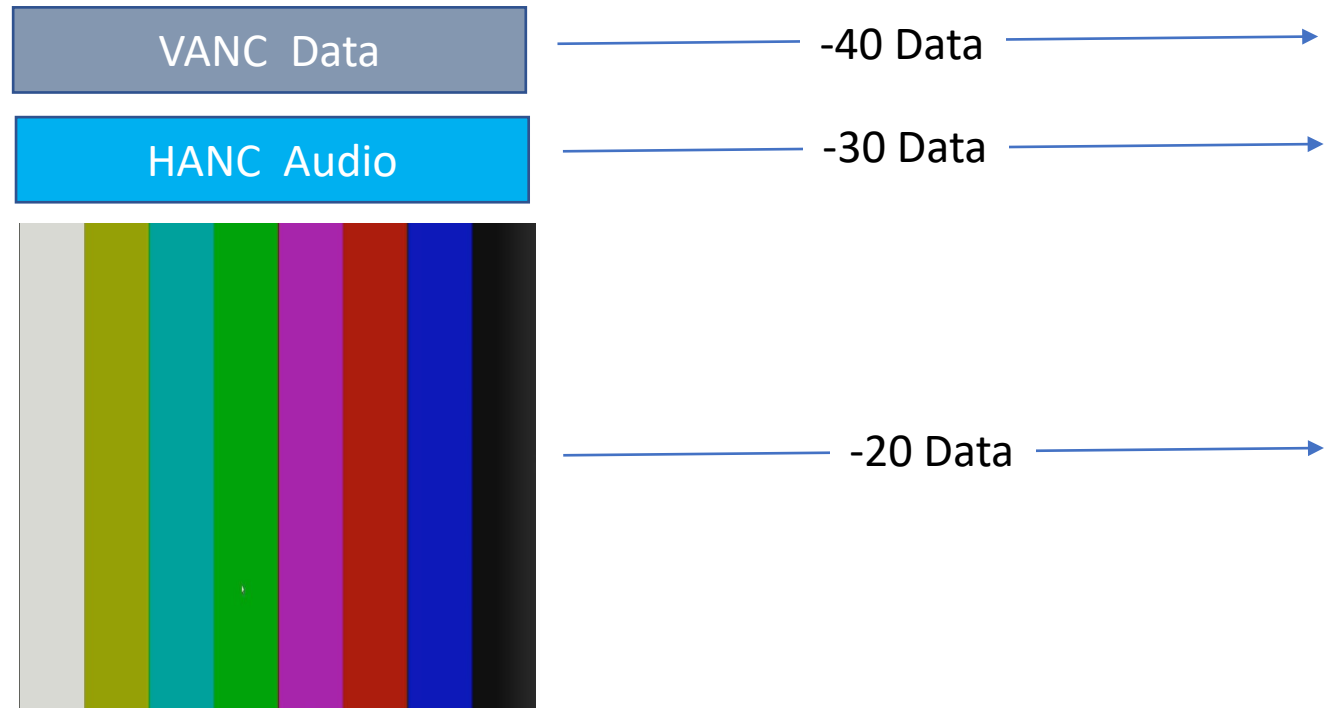
IP Transmission

- SMPTE ST 2022-6 saw us replicate SDI in a single RTP flow, using UDP Unicast/Multicast protocols



IP Transmission

- In IP we send Video, Audio and Data in (3) three different IP Multicast streams (essences).
- These different multicast streams can be on the same fiber, but they don't have to be.



SMPTE ST 2110

- ST 2110 uses separate Video, Audio and Metadata as essence payloads, or Flows.
- Uses essence over RTP/UDP
- Use PTP for synchronization (IEEE 1588 with SMPTE ST 2059-2 Profile).
- These three IP flows (essences) make up your program and are aka as a Service

ST 2110-20 Video



ST 2110-30 Audio



ST 2110-40 Data



Things we used to do – Analogue Video to SDI.

- With Analogue Video, we could hang an Oscilloscope on the video coaxial cable and look at it.
- We had to come up with a way to look at SDI, take 10 bits, make a Pixel out of it put that Pixel on the screen.
- With Analogue Audio, we could put an Oscilloscope on the Audio and see the Audio.
- With SDI we had to come up with a way to grab the channel that we wanted from the data out of the HANC and make an Audio waveform out of it.

Things we used to do – SDI to IP.

- SDI allowed us to carry the Audio and Captions (and several other things) in the Video payload. New tool sets and new ways were created to look at them.
- Well, we have done it again. We have moved everything around and put it on IP, not just IP but (3) three different IP Multicast flows.
- We need to find / make new tools to look at Video / Audio / Data (Captions) and make sure the Video / Audio / Captions etc., are compatible with being put back to SDI if needed.
- We will look at how to do this and see IP and SDI side-by-side.

Engineering verses Day to Day Work.

- Engineering IP Trouble shooting:
- You need a deep tool set to trouble shoot the IP layer.
 - IP Flow status, Packet Jitter, PTP timing, Buffers, 2022-7 and more
- But that's not what you need for day-to-day operations
- Production Day-to-Day operations;
 - Waveform, Vector, Captions, SCTE104, Audio Loudness, comparison of IP to SDI feed.

SDI Trouble shooting

- STATUS
- EYE
- JITTER
- TIMING

The screenshot shows a technical interface for SDI signal analysis. At the top, there are four rows of signal specifications: 1080i1080/50P YCbCr(422) 10bit 3G-A, 1920x1080/50P YCbCr(422) 10bit 3G-A, 1920x1080/50P YCbCr(422) 10bit 3G-A, and 1920x1080/59.94i YCbCr(422) 10bit HD. To the right, there are three 'SDI A' labels and one 'IP A' label, with corresponding time stamps: TIME: 20-22-20, TIME: 20-24-18, TIME: 20-25-12, and TIME: 19:56:37. A central white text box contains the text: 'Status, Eye and Jitter and timing are used to measure the integrity of the SDI signal'. Below the text box, there are controls for '-Advance' and '+Delay'. On the left side, there is a table with the following data:

CURR
V PHASE
0 Lines
TOTAL PH
-0.

At the bottom left, there are labels: REF EXT BB : DEFAULT and FORMAT: PAL.

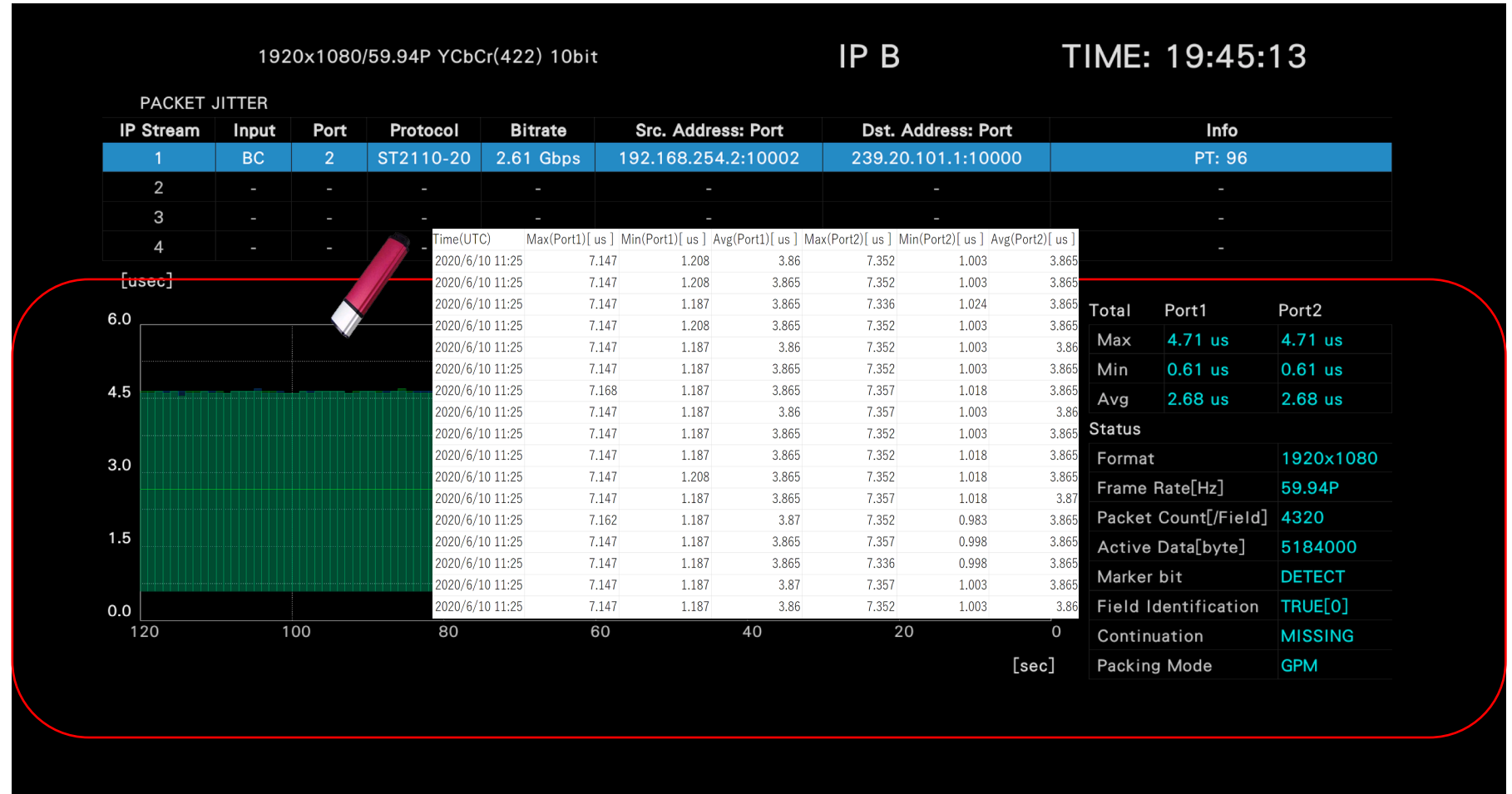
IP Trouble shooting

- As IP networks become more complicated, it is important to monitor each service.
- Confirm the protocol, data rate, Src. And Dst. address etc. of the received packets
- Monitor whether errors in packets occur.
- Monitoring traffic on each input IP port, as variations might indicate a network issue.

1920x1080/50P YCbCr(422) 10bit 3G-A		SDI A		TIME: 20:22:28	
STATUS					
	Signal	Format	Freq.	Cable	Embedded Audio
A CH	DETECT	1920x1080/50P 3G-A	-2.2ppm	< 10m	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16
ERROR					
SDI	A CH		ANC	A CH	
CRC	0		Check Sum	0	
TRS Position	0		Parity	0	
TRS Code	0				
Illegal Code	0				
Line Number	0				
Embedded Audio	A CH		Video Quality	A CH	
BCH	0		Freeze		
Parity	0		Black		
DBN	0		Gamut		
Inhibit	0		Cmp. Gamut		
Audio Sample	0		Level Y		
			Level C		
SinceReset 00:17:29					

IP Trouble shooting

- Excessive jitter results in large variances in inter packet arrival times.
 - Sustained jitter can mean burst or voids of packets.
- If packets are excessively delayed (a void) the receiver is starved.
 - Receive buffers are drained and the stream cannot be sustained.
- If packets are excessively bunched (a burst) the receiver is overloaded
 - Receive buffers are filled and video data must be discarded.
- Use Inter-Packet Arrival tools to visualize packet jitter.



GENERAL CAPTURE&DISPLAY NETWORK SNMP SER06(IP) REMOTE RS485 CAMERA ID TALLY OPERATION KEY DATE&TIME

Capture

Mode Screen

Signal Color Cyan

File Type

BMP BSG DPX TIFF FRM PCAP SDP

Transport Frame Number

1 Frame 16 Frames

PCAP Port (Port 1/2 Max 1MB, Ethernet Max10MB/60sec)

Port 1(SFP) Port 2(SFP) Ethernet(RJ45)

PCAP store PTP (Max 4KB)

Off On

Information Display

Format Off On

Input Off On

Icon Off On

Error Off On

Temperature Warning Off On

Date y/m/d

Time Off

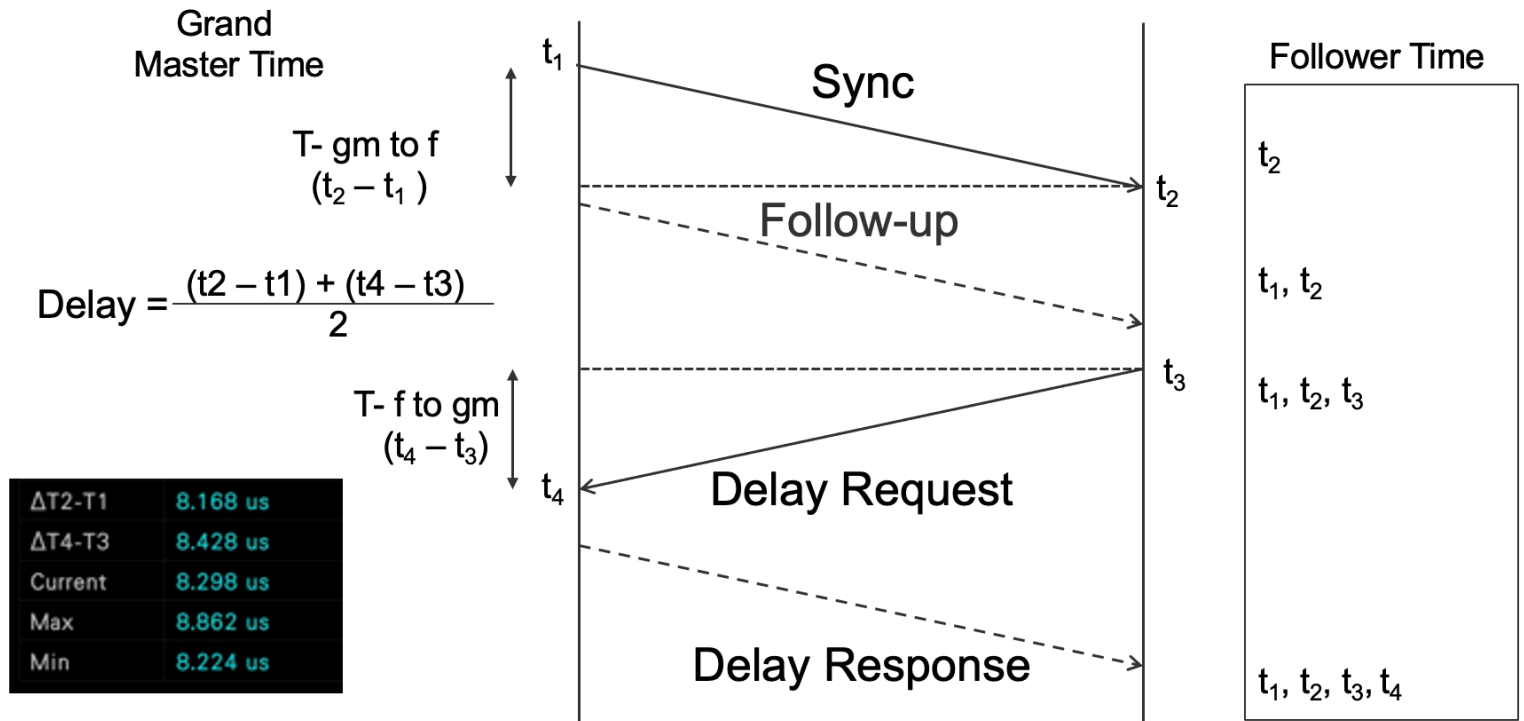
Time Zone Adjust +9:00

- With ST-2110, the timing information has been removed from the underlying hardware layer making the distribution asynchronous.
- BB / TLS reference is replaced by Precision Time Protocol (PTP)
- PTP is time-based, as opposed to phase based like BB / TLS

IP Trouble shooting

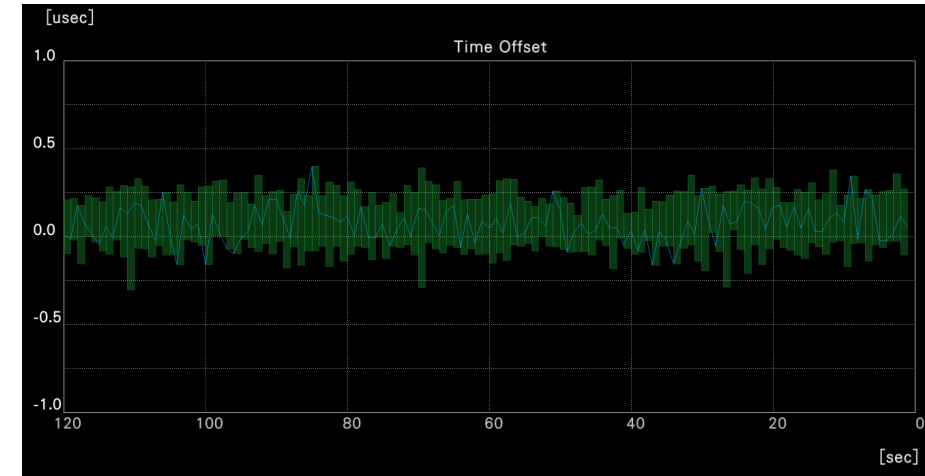
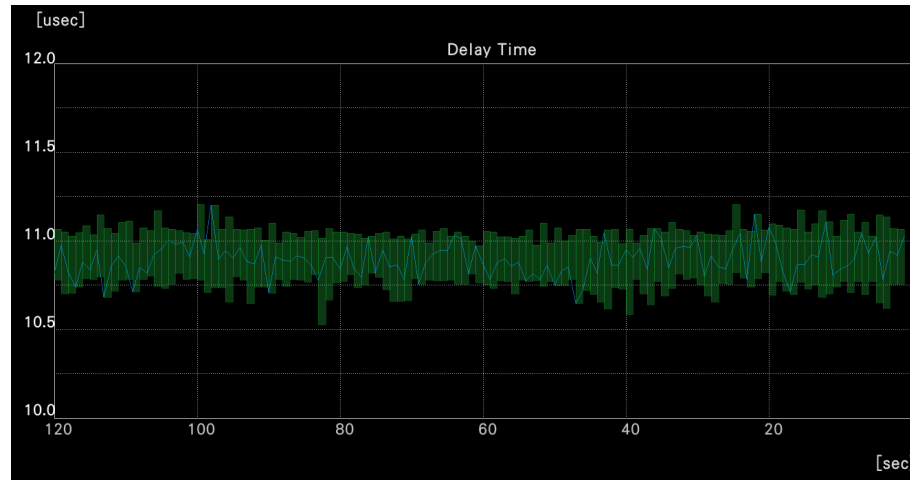
- PTP works by sending messages in both directions between the Grandmaster and Follower clock (device that is being timed) and using timestamps on those messages to determine the delays in the network and the offset in the client.

Used by Followers and Boundary Clocks



IP Trouble shooting

- One way to look at this, is PTP compensates for network delays and will adjust the Follower clock, using the measured difference in time between the Grandmaster and the Follower in time on the upstream and downstream paths.
- So, if the path delay on the two directions of a given path really are equal then the two clocks will be accurately aligned.



IP Trouble shooting

- Display synchronization status, time information and delay in PTP time synchronization.
- PTP STATUS GMID
- PTP DOMAIN
- Display max, min, measured value per second of PTP lock status, time information, network delay.
- Display PTP Message rates
- Network delay graph.

1920x1080/59.94P YCbCr(422) 10bit
IP C
TIME: 12:46:15

PTP STATUS GMID (Port1) 00-0c-17-ff-fe-88-20-51 / (Port2) 00-0c-17-ff-fe-88-20-51

Port	Protocol	Bitrate	Src. Address: Port	Dst. Address: Port
1	PTP(Gen)	17.79 kbps	192.168.1.200:320	224.0.1.129:320
1	PTP(Evt)	5.50 kbps	192.168.1.200:319	224.0.1.129:319
2	PTP(Gen)	17.79 kbps	192.168.1.200:320	224.0.1.129:320
2	PTP(Evt)	5.50 kbps	192.168.1.200:319	224.0.1.129:319

Info

DOMAIN: 44

DOMAIN: 44

DOMAIN: 44

DOMAIN: 44

Timing	Port1	Port2
State	LOCK	READY
Time(UTC)	2022/01/14 03:45:25	
ΔT2-T1	6.126 us	5.070 us
ΔT4-T3	4.796 us	4.772 us
Current	5.461 us	4.921 us
Max	6.387 us	6.124 us
Min	3.926 us	3.918 us

Packet count (/ sec)

Sync	8	8
Follow up	8	8
Delay request	8	8
Delay response	8	8
Announce	1	1
Management	0	0

[usec]

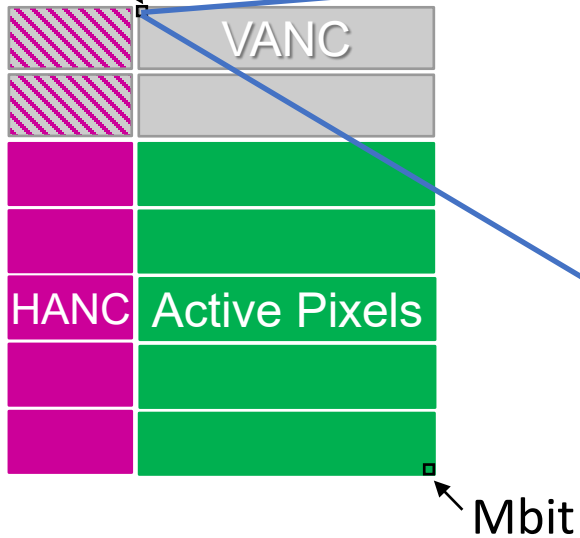
Delay Time

[sec]

- Once we are confident that our PTP reference is stable, we can start to investigate the timing of each of the SMPTE ST 2110 Multicast flows.
- With ST-2110-20 the video stream only contains the active pixels.
- Which brings with it a new series of measurement challenges.

RTP / PTP Timing – ST.2110

The start of PTP is normally the same as the start of Black, Line 0, Pixel 0



1920x1080/59.94i YCbCr(422) 10bit
IP A
TIME: 00:19:40

PTP-BB PHASE

CURRENT PHASE	
V PHASE	H PHASE
0 Lines	0.121 us
	9 pixel
TOTAL PHASE	
0.121 us	

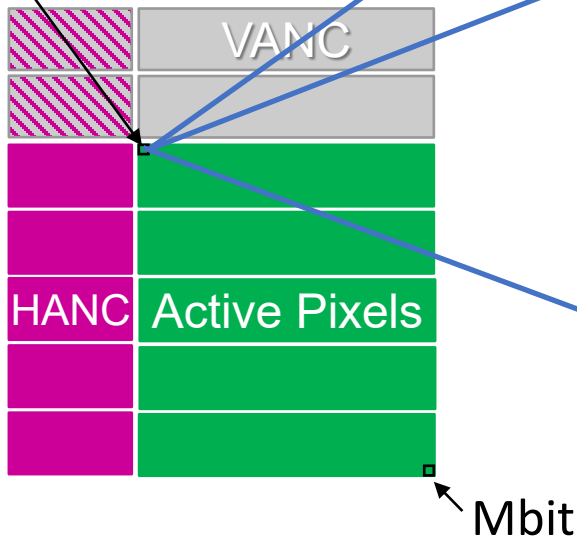
REF PTP
EXT FORMAT: 1920x1080/59.94i

The timing diagram shows a central vertical line with a circle at its base. To the left, a horizontal bar labeled '-Advance' extends to the left. To the right, a horizontal bar labeled '+Delay' extends to the right. Below the vertical line, another horizontal bar labeled '+Delay' extends to the left.

RTP / PTP Timing – ST.2110

The start of PTP is normally the same as the start of Black, Line 0, Pixel 0

But active video starts 21 lines later for 1080i or 42 lines later for 1080p



1920x1080/59.94i YCbCr(422) 10bit HD

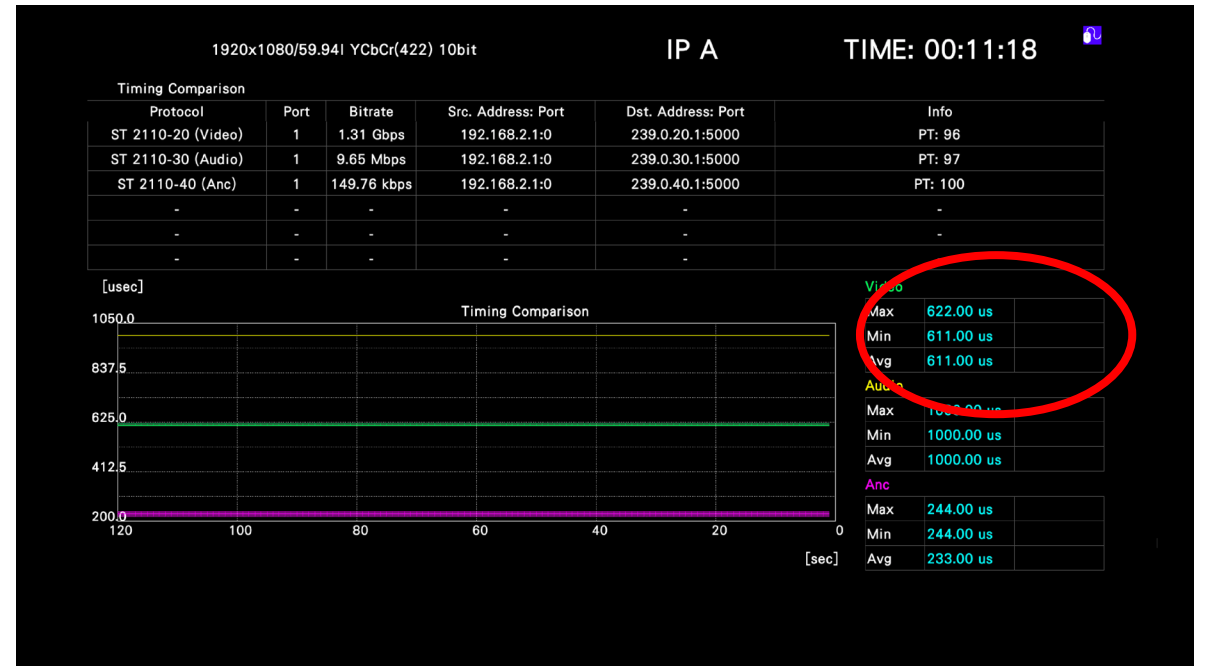
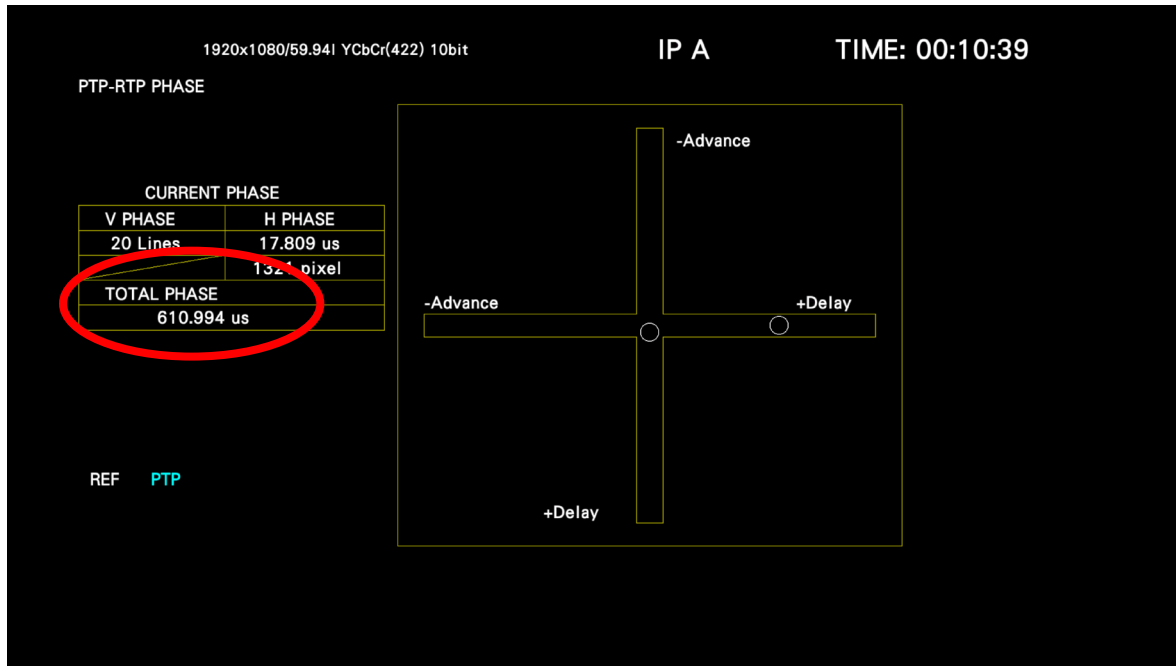
IP A TIME: 10:21:51

CURRENT PHASE	
V PHASE	H PHASE
21 Lines	4.152 us
308 pixel	
TOTAL PHASE	
626.997 us	

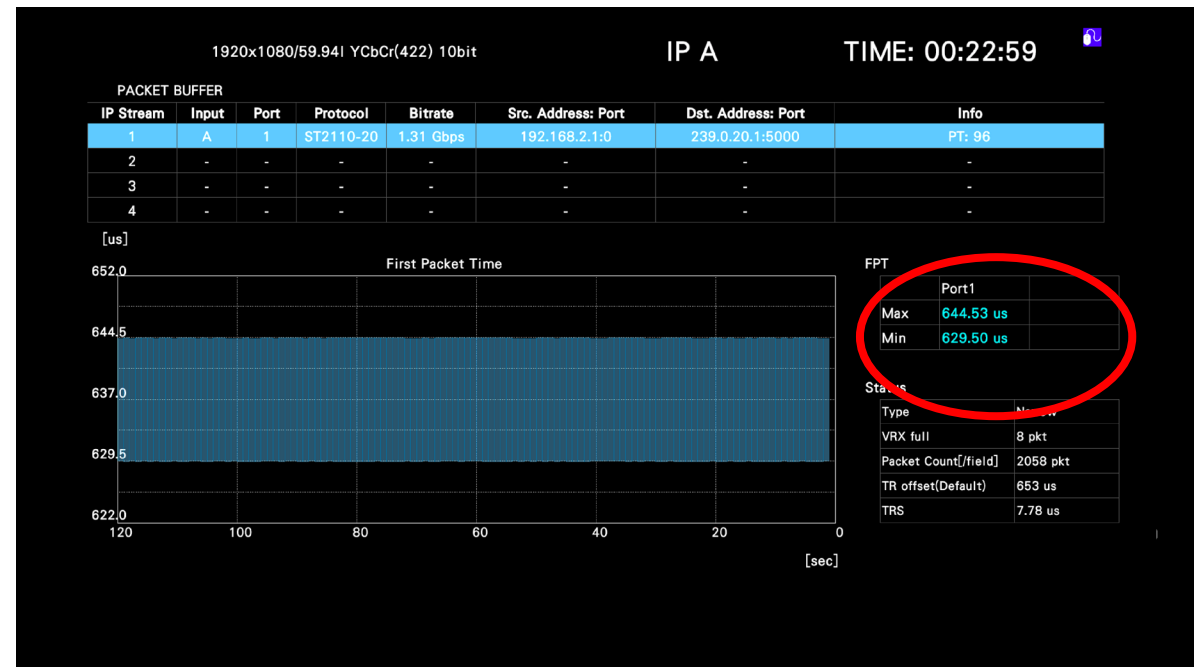
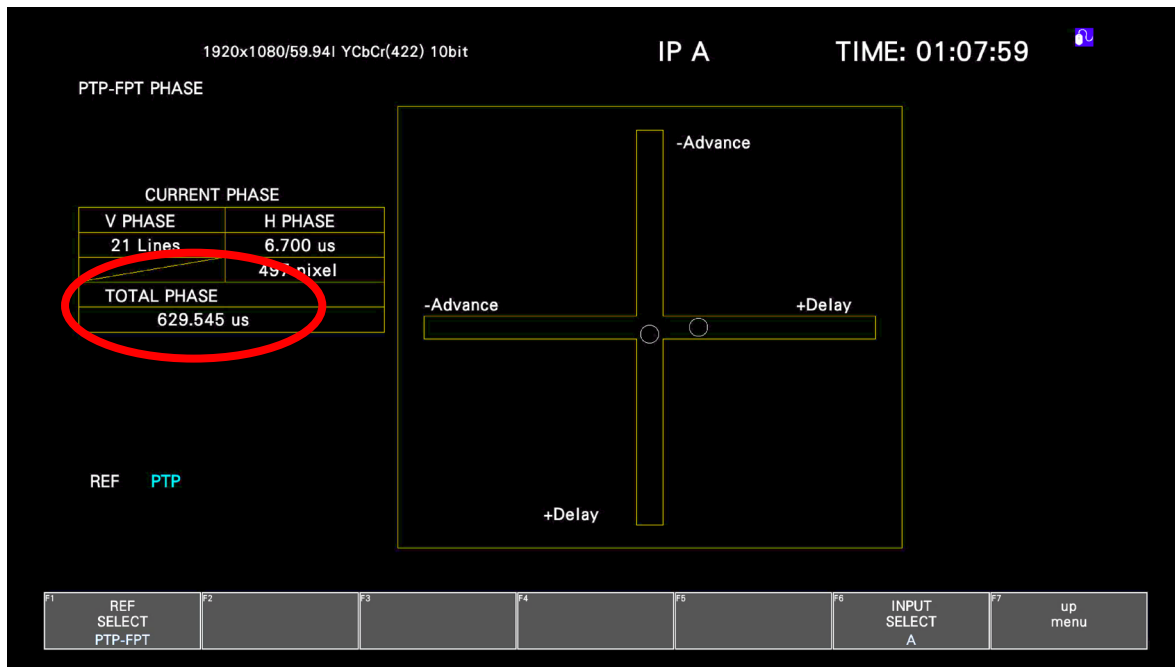
REF PTP
FORMAT:

The timing diagram shows a central vertical bar with two horizontal bars intersecting it. The top horizontal bar is labeled '-Advance' and the bottom horizontal bar is labeled '+Delay'. The vertical bar has two small circles on it, one at the top and one at the bottom, representing the start of the PTP signal.

Timing Comparison

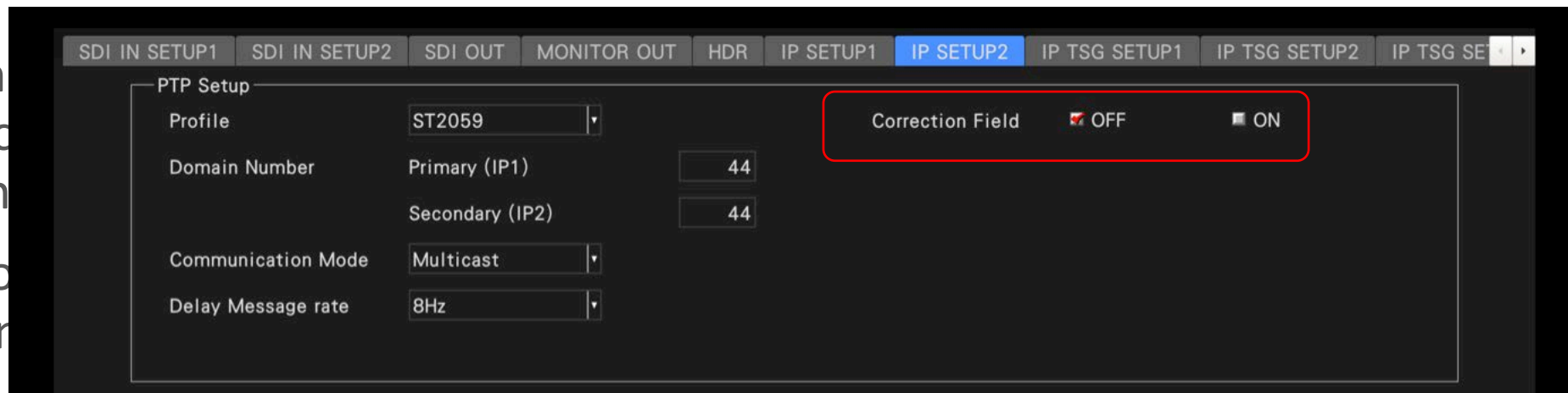


1st Packet Arrival Time



- If the Timing Comparison displays and the 1st Packet Arrival Time graph are outside the expected timing range and no image is being displayed, there is one further test you can employ.
- On the Leader test and measurement products you can switch the 'Timestamp Mode' to OFF.

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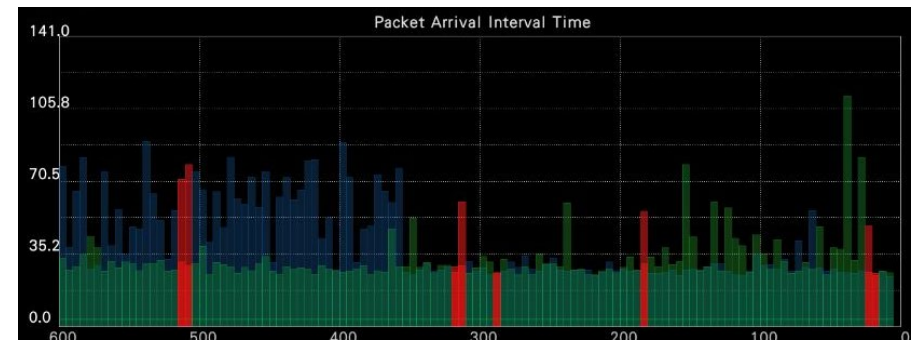


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IP Trouble shooting

- Transmission Errors – Dropped Data
- SDI we look at CRC errors
- In IP we look at RTP errors
 - CRC Errors will not pass through an IP Switch

ERROR	
SDI	A CH
CRC	0
TRS Position	0
TRS Code	0
Illegal Code	0
Line Number	0



Video1 RTP Sequence, Interval Variation

IP Trouble shooting

- The Event Log now contains a completely new set of fault parameters.

- FCS Error
- IP CS Error
- UDP CS Error
- Video RTP Sequence
- Mbit Stream 1,2,3,4
- Interval Variation 1,2,3,4
- PTP ClockClass
- Video CMAX
- Video VRX
- PTP Unlock Error
- PTP GMID Exist
- Video RTP Timing
 - Threshold
- ANC RTP Timing
 - Threshold

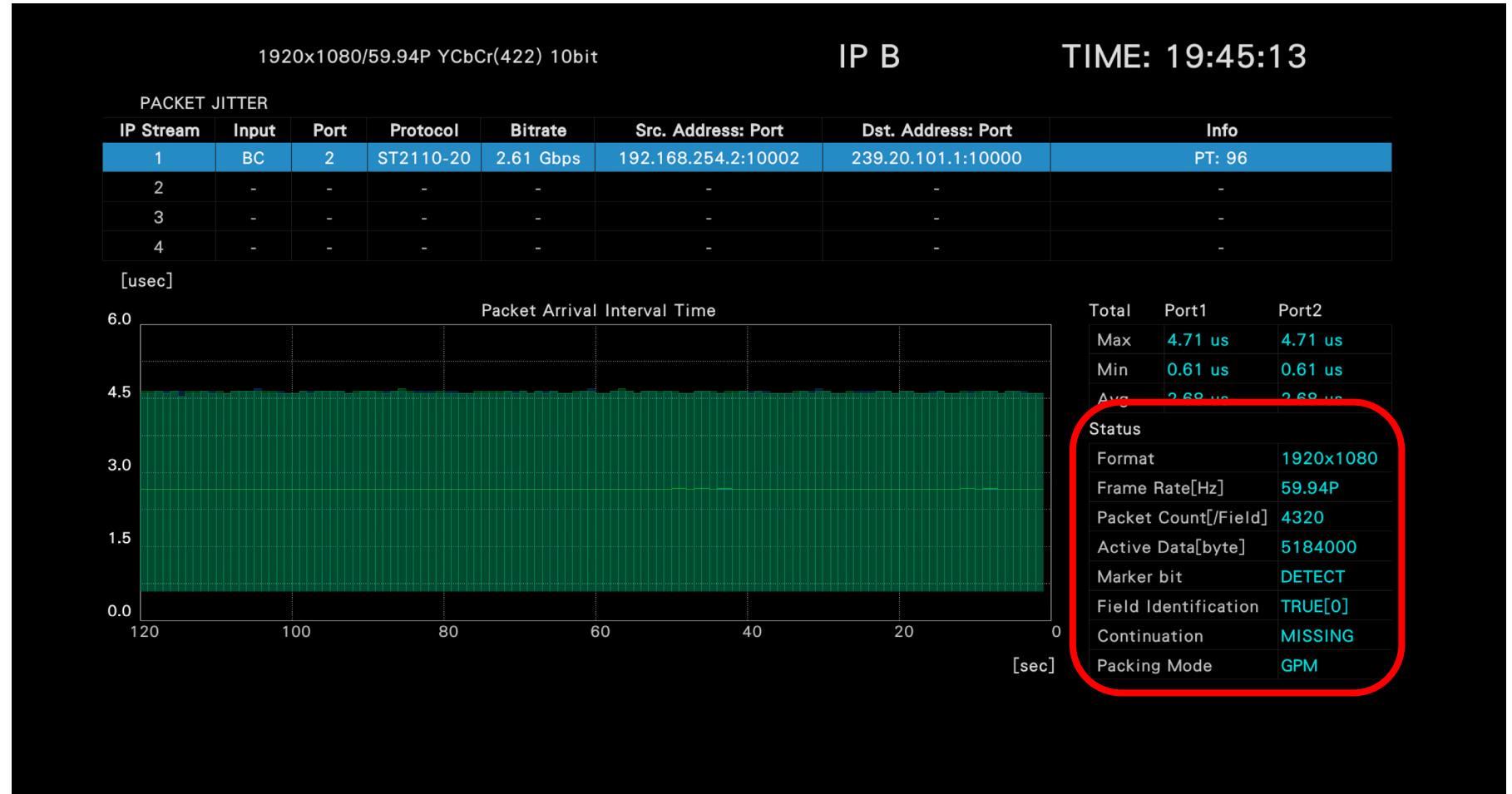
1920x1080/50I YCbCr(422) 10bit
IP B
TIME: 15:43:28

EVENT LOG LIST	SAMPLE No.40	<< NOW LOGGING >>
9: 2022/04/12 15:36:27	IP2 LINK UP	GMID:00-0c-17-ff-fe-4c-62-05,PTP Unlo...
8: 2022/04/12 15:36:24	IP1 LINK UP	GMID:00-0c-17-ff-fe-4c-62-05,PTP Unlo...
7: 2022/04/12 15:35:29	A 720x487/59.94I	
6: 2022/04/12 15:35:29	D 720x487/59.94I	
5: 2022/04/12 15:35:29	C NO SIGNAL	
4: 2022/04/12 15:35:29	B NO SIGNAL	
3: 2022/04/12 15:35:29	- EMB-AUDIO	
2: 2022/04/12 15:35:29	IP1 LINK UP	PTP Unlock,
1: 2022/04/12 15:35:29	IP2 LINK UP	PTP Unlock,

FCS	IP CS	UDP CS	
Video1 RTP Sequence	Video2 RTP Sequence	Video3 RTP Sequence	Video4 RTP Sequence
Mbit Stream1	Mbit Stream2	Mbit Stream3	Mbit Stream4
Interval Variation1	Interval Variation2	Interval Variation3	Interval Variation4
PTP Unlock	PTP GMID	PTP ClockClass	
Video1 RTP Timing	Video2 RTP Timing	Video3 RTP Timing	Video4 RTP Timing
Audio1 RTP Timing	Audio2 RTP Timing	Audio3 RTP Timing	Audio4 RTP Timing
ANC1 RTP Timing	ANC2 RTP Timing	ANC3 RTP Timing	ANC4 RTP Timing
Video1 CMAX	Video2 CMAX	Video3 CMAX	Video4 CMAX
Video1 VRX	Video2 VRX	Video3 VRX	Video4 VRX

IP Trouble shooting

- ST 2110-20 video stream only contains the active pixels.
- Video frame rate and sampling rate are determined on the STATUS -> Packet Arrival Time display from RTP timestamp.



IP Trouble shooting

- By being able to view simultaneously multiple IP analysis tools, engineers can quickly and efficiently identify where the networking issues lies.
- Whilst at the same time still having access to the traditional waveform, timing and picture display tools they are familiar with from SDI based facilities

1920x1080/59.94P YCbCr(422) 10bit

No	IP Stream	Input	Port	Protocol	Bitrate	Src. Address: Port	Dst. Address: Port	Info
1	1	BC	2	ST2110-20	2.61 Gbps	192.168.254.2:10002	239.20.101.1:10000	PT: 96
2	1	BC	2	ST2110-30	9.65 Mbps	192.168.254.2:10003	239.30.101.1:10000	PT: 97
3	-	-	2	PTP(Gen)	12.50 kbps	192.168.254.1:320	224.0.1.129:320	DOMAIN: 44
4	-	-	2	PTP(Evt)	5.50 kbps	192.168.254.1:319	224.0.1.129:319	DOMAIN: 44

PTP STATUS: PTP(Port1) Not Detect, PTP(Port2) Unlock:00-0c-17-ff-fe-4c-62-05

Port 1: LINK DOWN
Port 2: LINK UP

Bitrate: 2.623826 Gbps
FCS Error count: 1276
IP CS Error count: 0
UDP CS Error count: 0

IP B TIME: 01:15:40

PTP-BB PHASE

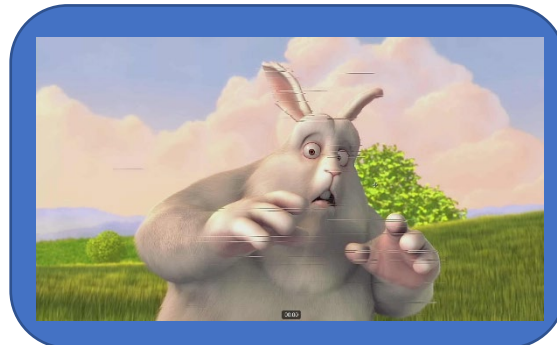
CURRENT PHASE: V PHASE 0.000 us, H PHASE 0.000 us, 0 Lines, 3 pixels, TOTAL PHASE 0.000 us

REF PTP EXT FORMAT: 1920x1080/59.94

Leader

YCbCr

- Every device may show the errors in a picture a little differently, it is all depends on how they build the picture.
- In 1080i one IP packet is about $\frac{1}{4}$ of a line, that's how much data will be lost for one packet error.
- Some are going break up randomly
- Some will have lines of bad pixels jumping all over the place
- Some will go to black on the error



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IP Trouble shooting

- Picture Breakup
 - Slice



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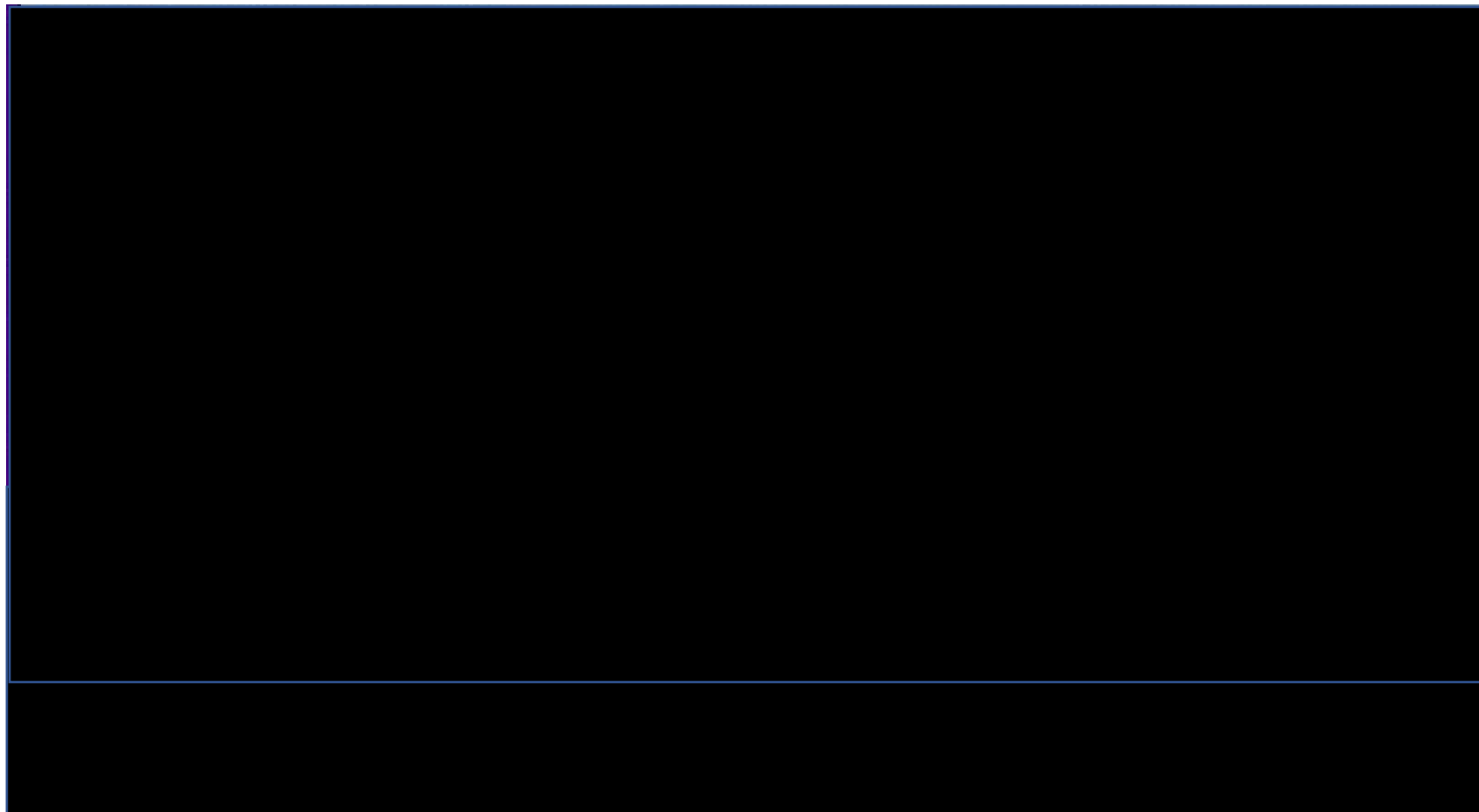
IP Trouble shooting

- Picture Breakup
 - Pixel Lines



IP Trouble shooting

- Picture Breakup
 - Blackout



- So, we've established that our IP network is operating correctly.
- We now need a suite of analysis tools for Day-to-Day production that operate in both IP and SDI infrastructures.
- Remember – IP is just another I/O interface – its how we analysis it.

Day-to-Day Operations

- Although the transport layer has changed, color management of images remains the same.
- Camera shaders don't care if the source signal is IP or SDI
- You need test and measurement tools that can display both IP and SDI simultaneously (aka as 'True Hybrid' Operation)



Day-to-Day Operations

- The same applies to the traditional 'Quad-split' display.
- Only the STATUS display is different

1920x1080/59.94P YCbCr(422) 10bit 3G-B-DL EXT

SDI A TIME: 00:15:33

1920x1080/59.94P YCbCr(422) 10bit

IP B TIME: 00:15:30

SDI Status

IP Status

IP STATUS	Port	Protocol	Bitrate	Src. Address Port	Dst. Address Port	Info	
1	IP	BC	1	192.168.254.1:10000	238.28.103.1:10000	PI: 94	
2	1	BC	1	192.168.254.1:10001	238.28.103.1:10000	PI: 97	
3	1	BC	2	192.168.254.2:10002	238.28.101.1:10000	PI: 96	
4	1	BC	2	192.168.254.2:10003	238.28.101.1:10000	PI: 97	
5	-	-	1	PTP(Gen)	192.168.254.1:320	224.0.1.129:320	DOMAIN: 44
6	-	-	1	PTP(Src)	192.168.254.1:319	224.0.1.129:319	DOMAIN: 44

BT.2020

x1,000

COMPONENT

SDI Status

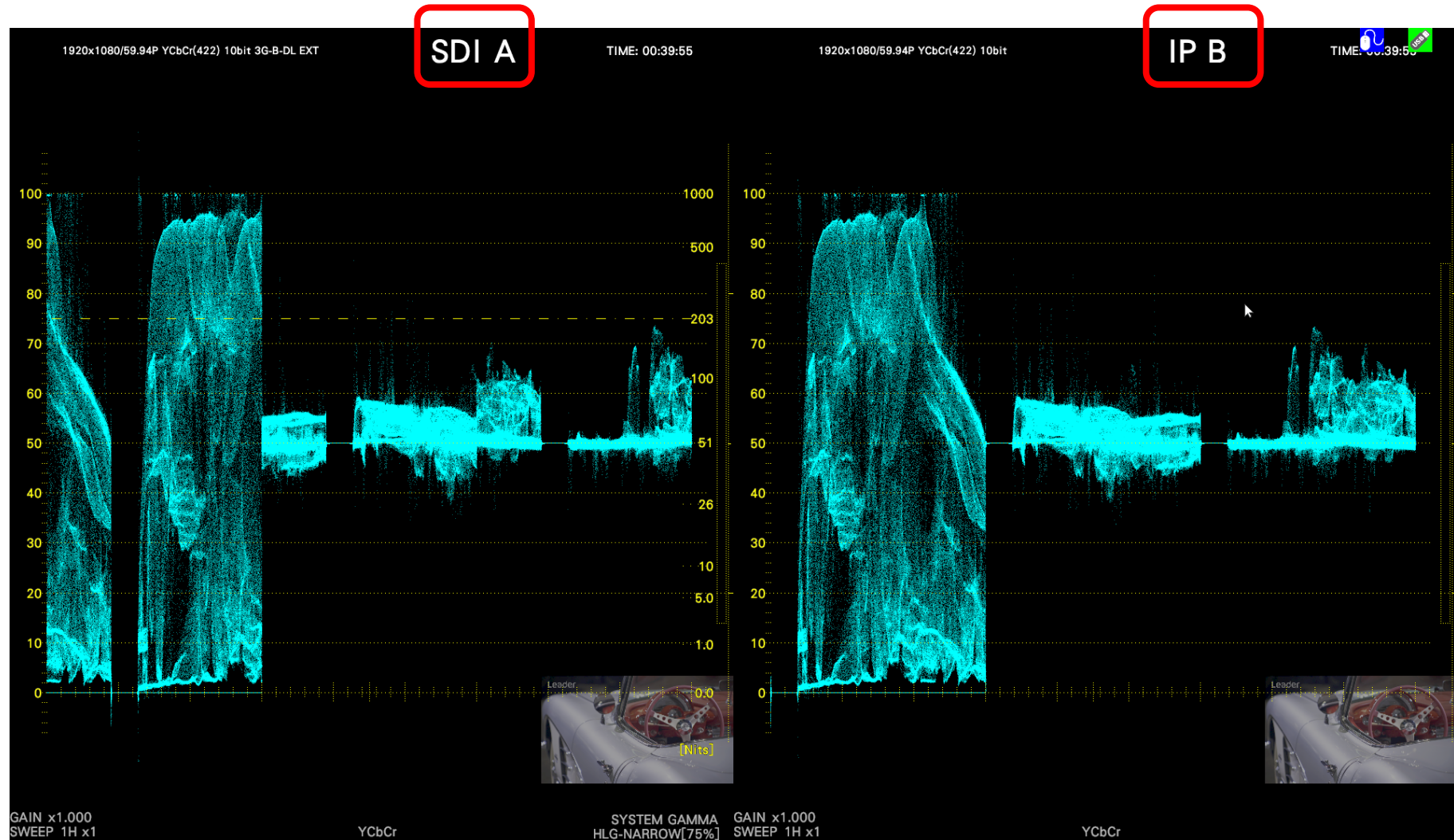
IP Status

x1,000

COMPONENT

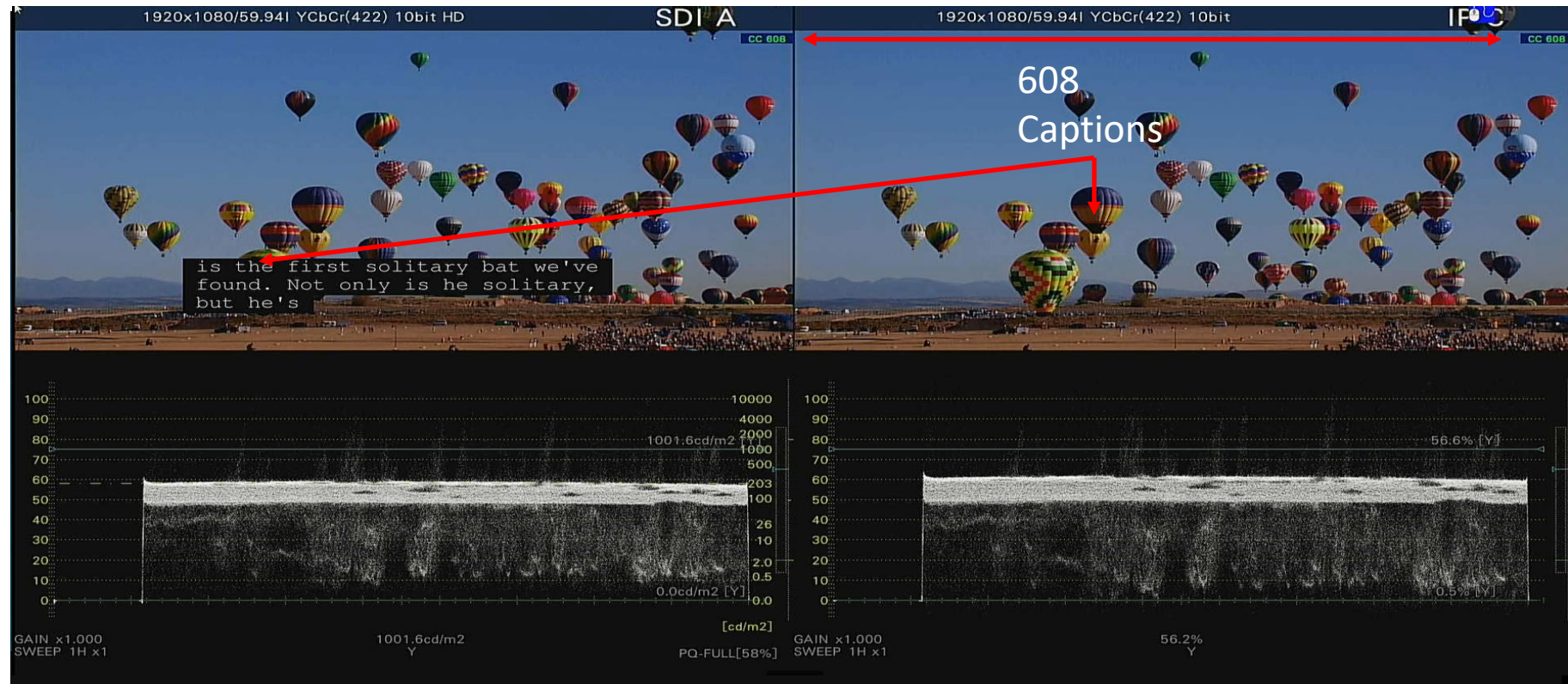
Day-to-Day Operations

- With the customizable layout license, analysis tools can be freely sized, positioned and even overlaid depending on the operator preference.
- Irrespective of whether the video source is IP or SDI



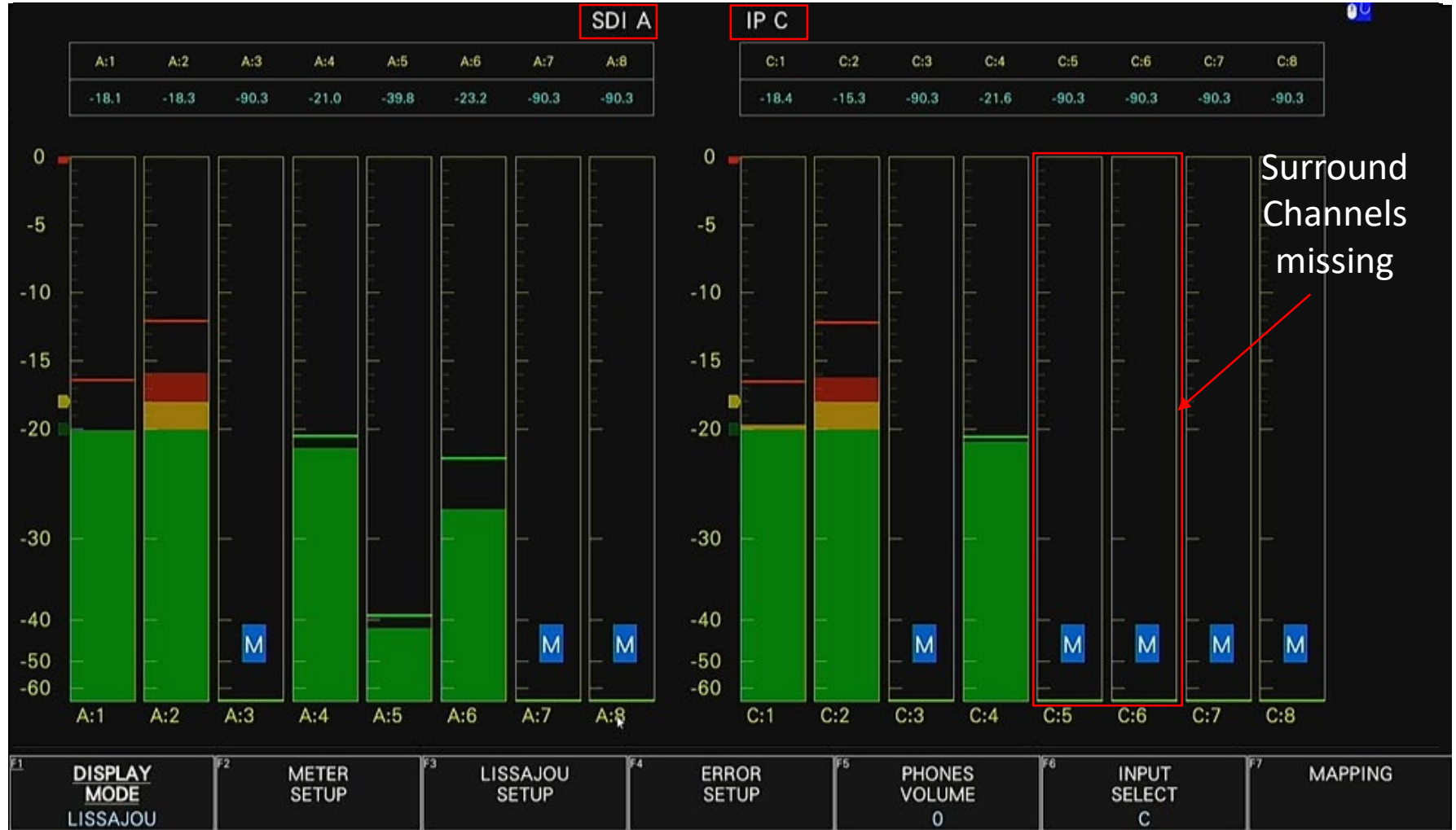
Day-to-Day Operations

- 'True Hybrid' operation allows you to ensure ancillary data like closed captions are present.
- Multiple analysis tools like PIC and WFM can be displayed in both IP and SDI.



Day-to-Day Operations

- The same applies to Audio Analysis of -30 or -31 audio stream and SDI embedded audio.



Day-to-Day Operations

- The same applies to ANC Data Analysis of -40 ANC Data stream and SDI embedded audio.

PAYLOAD ID DISPLAY SMPTE ST352		PAYLOAD ID DISPLAY SMPTE ST352	
INTERFACE LINE No.	10	INTERFACE LINE No.	10
BYTE1	10001001 [89]	BYTE1	10000101 [85]
VERSION ID	SMPTE ST352-2011	VERSION ID	SMPTE ST352-2011
PAYLOAD ID	1125(1080) LINE	PAYLOAD ID	1125(1080) LINE
DIGITAL INTERFACE	3Gb/s LEVEL-A	DIGITAL INTERFACE	1.485Gb/s
BYTE2	11001010 [CA]	BYTE2	00001010 [0A]
TRANSPORT STRUCTURE	PROGRESSIVE	TRANSPORT STRUCTURE	INTERLACED
PICTURE STRUCTURE	PROGRESSIVE	PICTURE STRUCTURE	INTERLACED
HDR / SDR	SDR	HDR / SDR	SDR
PICTURE RATE	60/1.001	PICTURE RATE	60/1.001
BYTE3	00000000 [00]	BYTE3	00100000 [20]
ASPECT RATIO	UNKNOWN	ASPECT RATIO	16:9
H SAMPLING	1920	H SAMPLING	1920
COLORIMETRY	REC 709	COLORIMETRY	REC 709
SAMPLING STRUCTURE	4:2:2 YCbCr	SAMPLING STRUCTURE	4:2:2 YCbCr
BYTE4	00000001 [01]	BYTE4	00000001 [01]
CHANNEL ASSIGNMENT	NOT USED	CHANNEL ASSIGNMENT	NOT USED
LUMINANCE / COLOR	YCbCr	LUMINANCE / COLOR	YCbCr
AUDIO EMB MODE	NOT USED	AUDIO EMB MODE	NOT USED
BIT DEPTH	10BIT	BIT DEPTH	10BIT

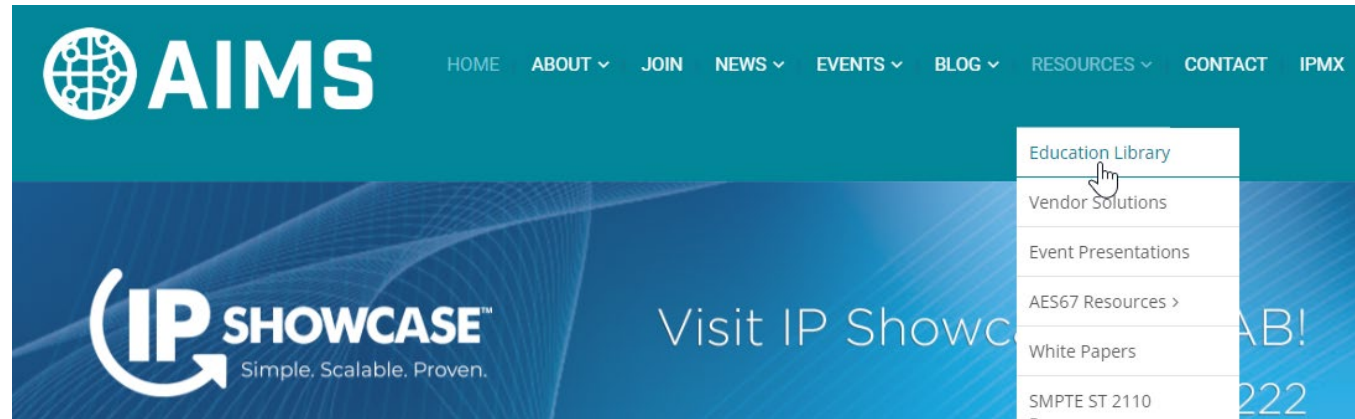
- Remember – IP is just another I/O interface – its how we analysis it.
- IP Networks don't typically 'drop off a cliff' and fail, they gradually drift.
 - So having test and measurement products that can monitor your IP network over a prolonged period is vital.
- You need tools that will still show you errors that you can relate back to SDI
 - So having analysis tools that allow you to see Inputs side-by-side, irrespective of whether they are IP or SDI are invaluable.
- You need timing tools to verify that your SDI and IP are locked to the same clock
 - So, connections and analysis of both PTP and BB / TLS are essential.
- You need simple user configurable Multi View screen.
 - The traditional 'Quad-Split' display is no longer sufficient.

Leader PHABRIX® Pipes are now Packets



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info@aimsalliance.org



Steve Holmes



Kevin Salvidge

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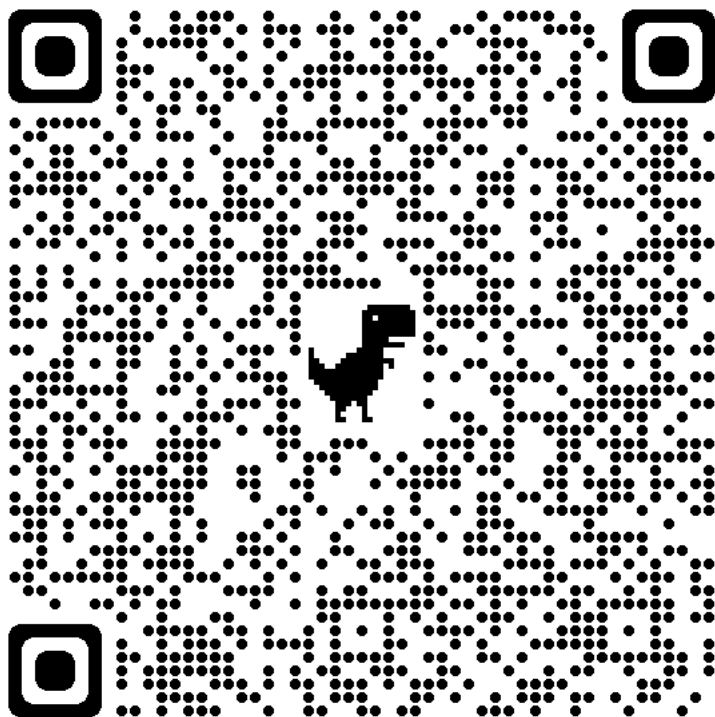
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- If you like more information including a copy of this presentation.



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