

Design considerations in the use of IP for UHD mobile television production

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1916-2016



grass valley

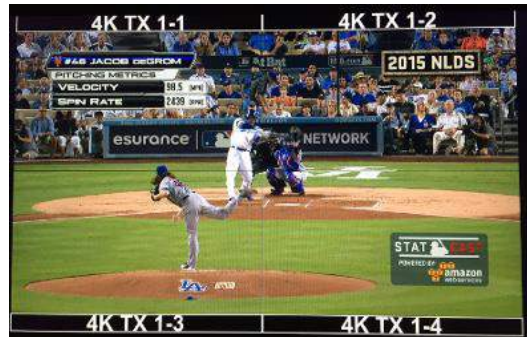
A **BELDEN** BRAND



the proper tool for the task at hand?

Momentum is gaining for UHD live production

- ❖ Several professional sports leagues and networks are now active in launching UHD coverage of their games
- ❖ Many new mobile production trucks/OB vans launched in the last 12 months
- ❖ However, the design and core technologies utilized in production of UHD continues to evolve



Momentum is gaining for UHD live production

Croatel OB5



Al Kass OB10



Dome Pioneer



NEP UHD41



SBS UHD4K

Broad range of designs – and UHD capabilities

➤ Notable OB vans launched in recent months:

	Croatel OB5 (Zagreb)	SBS UHD 4K (Seoul)	Al Kass OB10 (Qatar)	NEP UHD41 (Zurich)	Dome Pioneer (Toronto)	Arena OBX (London)
UHD	Yes	Yes	No	Yes	Yes	Yes
Operators	17?	17	29	19	22	43
Cameras	16 UHD 20 X HD	12 UHD	11	12	10	32
Replay channels	2 X 3 UHD channels	2 X 3 UHD channels	9 X 12 HD channels	4 X 4 channels	5 X 3 channels (wired for 12)	12 X 4 channels
Router Matrix	288 x 576 (3G)	128 X 128 (12G)	288X450 (3G)	256X328 (3G)	135 X 112 UHD	2.88 Tbps IP
Core infra		12G SDI	3G SDI	3G SDI	3G SDI	IP





The Challenge

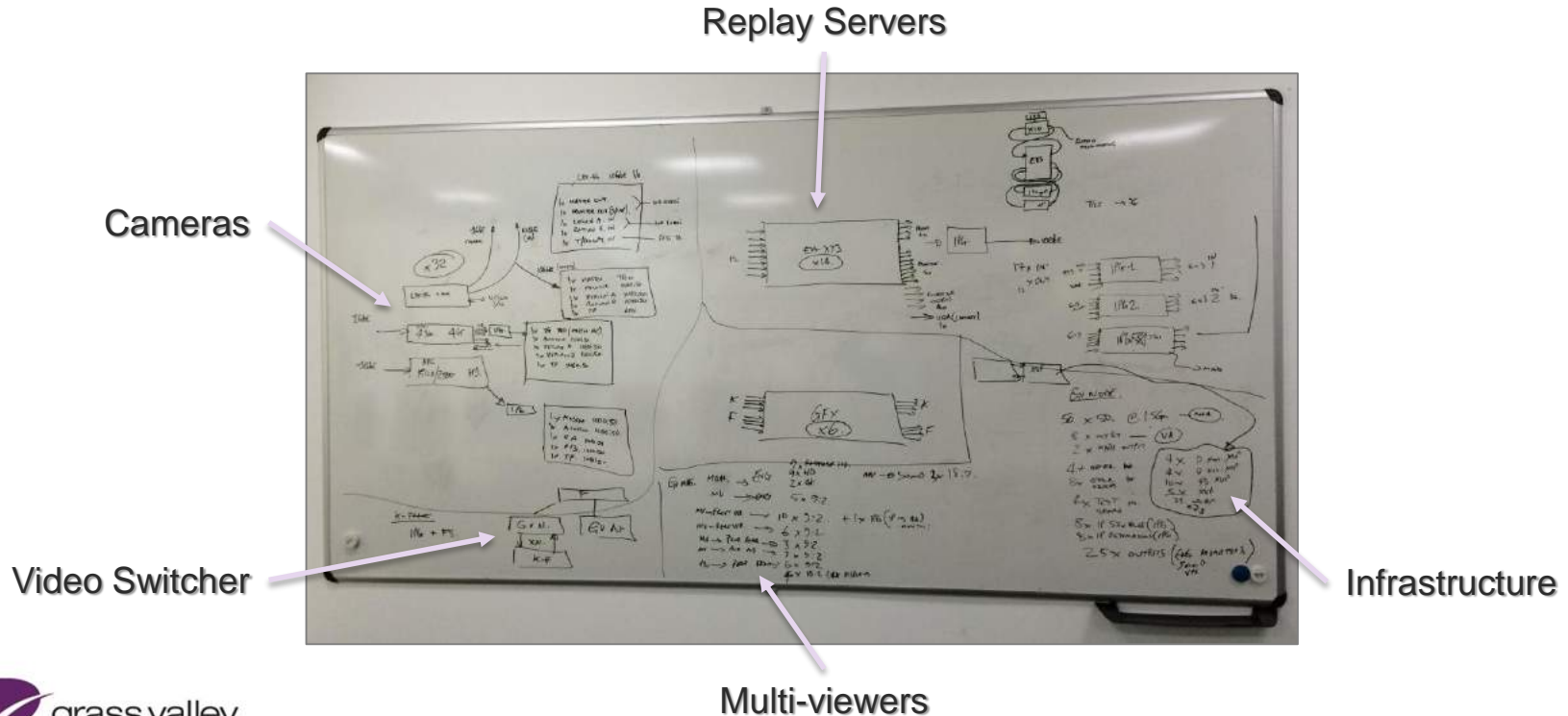
- ❖ Grass Valley was approached late Summer 2015 by Arena Television to contribute to the design of an IP-based live production solution for premier sporting events
- ❖ Arena's core requirements:
 - COTS based infrastructure - Cisco, Arista, Juniper or HP – No Redundancy
 - Standards based – SMPTE ST 2022-6, AES 67, TR04 and TR03 (SMPTE ST 2110), RDD 35 (TICO)
 - Signal agnostic - UHD 2160p50, 3G 1080p50 and HD 1080i50
 - Future-ready - HDR (High Dynamic Range) and HFR (High Frame Rate)
 - Reduction in cabling – including less weight and easier access to equipment
 - Of course ... as cost neutral to an equivalent Quad-SDI based solution as possible!

The Challenge

- ❖ OB Truck (Triple Expander) technical requirements:
 - 32 x UHD Cameras
 - 12 x UHD Replay Systems (4 in / 2 out)
 - 1 x UHD Video Switcher (48 in / 24 out)
 - 47 x 3G/HD Multi-viewers (486 unique sources)
 - Extensive IP/SDI Connectivity with Video & Audio Processing
 - Complex TX paths (UHD, 3G, HD, SD)
 - Flexible Tailboard (Bi-directional I/O)
 - External IP frames for Graphics and Presentation trucks
 - Ability to connect multiple OB trucks together via IP infrastructure (100GbE)

Where did we start?

As with most complex system designs ... scribbling on a whiteboard ...



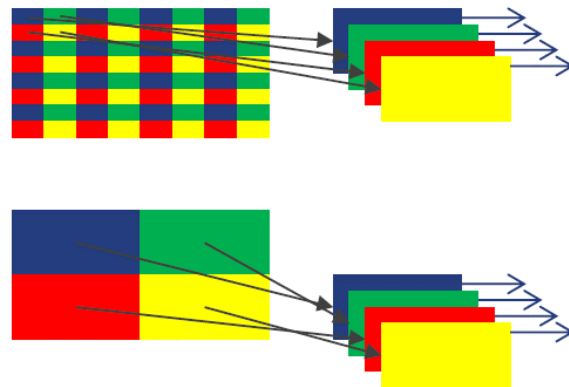
TICO Mezzanine compression

- ❖ Effective way to transport multiple streams of UHD over 10Gb
- ❖ Light way compression, 4:1, reducing UHD to the size of 3G.
- ❖ Visually lossless – indistinguishable image loss over multiple generations.
- ❖ Very low latency:
 - Encoding is 4.5 vertical line
 - Decoding is 2.5 vertical line.
- ❖ TICO SMPTE RDD35:
 - Transport TICO as a 3G-SDI signal over ST 2022-6
 - Future support for ST 2110-20 to transport TICO as a compressed essence



Uncompressed UHD transport

- ❖ Quad Link SDI at 3G per coax SMPTE ST 424-5
 - 2SI = 2 Sample Interleave
 - 4 sub images used to alternate sampling every 2 pixels and every line.
 - This the method defined in all UHDTV specifications and the prefer method
 - Low Latency – 1 line of inherent delay!
 - SDQS = Square Division Quad Split
 - Image is split into 4 quadrants.
 - Used by most 1st generation equipment
 - ½ frame of inherent delay.



End-point Device – Cameras



❖ Cameras Operational Modes

- Native UHD Sensor
- Native TICO Support
- IP Gateway Interface (1 x 10GbE)
- Main & Monitor Outputs via IP
- Camera Returns & TP via IP
- XML Interface for Device Control

10 GigE IP Fiber and Ethernet connectivity

- Scalable from “just” video to a full IP production
- 4K over 1 wire with TICO



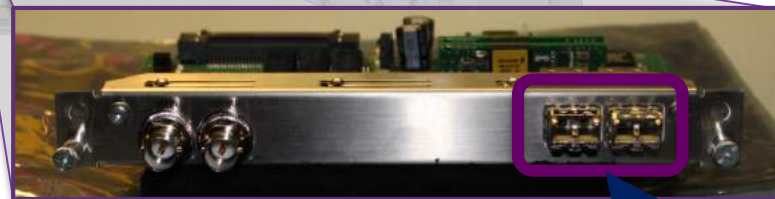
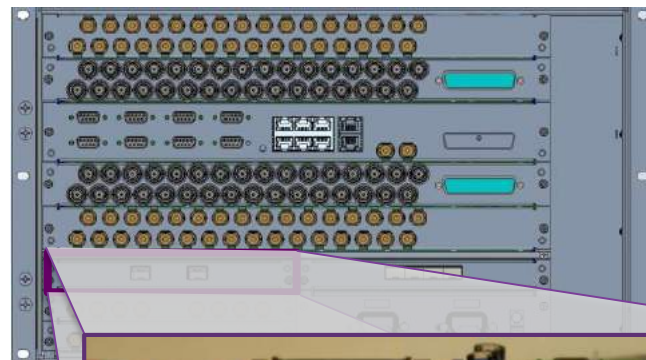
End-point Device – Production Switcher

❖ Video Switcher Operational Modes

- 4ME Mode in UHD 2160p50
- 2-Sample Interleave Support
- IP Gateway Interfaces (10GbE)

❖ Enhancements

- Native TICO Support
- 1080p50 Monitoring Stream



**Modular IP I/O
(2 x 10GbE SFP+)**

End-point Device – IP Gateways



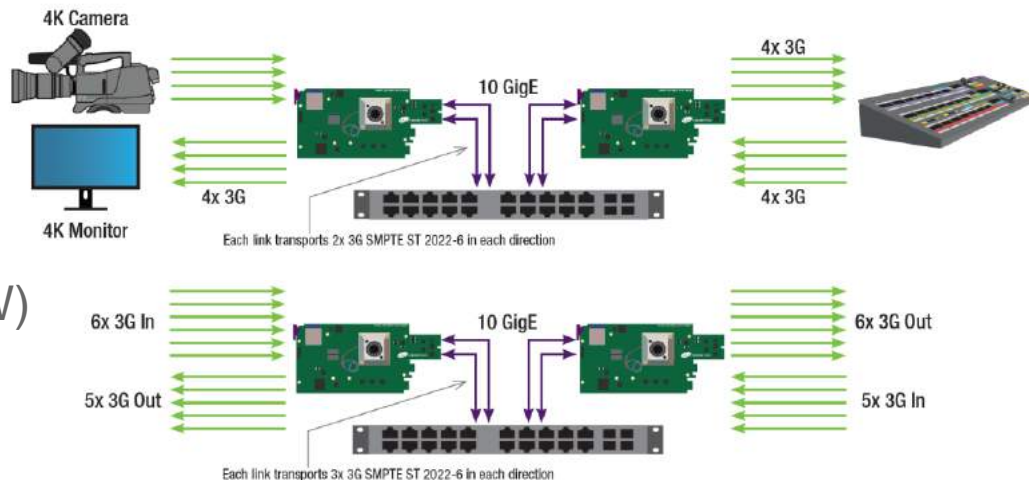
❖ IP SDI Gateway Cards

❖ Operational Modes

- HD 1080i50 (11 x GW)
- 3G 1080p50 (6 x GW)
- UHD 2160p50 / TICO (2 x GW)

❖ Enhancements

- Aggregation Mode (2 x 10GbE)
- Square Division Quad Split (SDQS) to/from 2-Sample Interleave (2SI)



IP Aggregation

- ❖ IP Gateways to “Bridge” native IP and legacy SDI equipment



Signal	Camera IP			Camera SDI		
	Native IP		Via IP Gateway	Native IP		Via IP Gateway
	UHD	HD/SD		UHD	HD/SD	
Program Output	*					*
Monitor Super Output		*				*
Return Input		*				*
Return Input		*				*
Tele Prompted Input		*				*
Monitor Clean Out			*			*
Return Input C			*			*

IP Aggregation

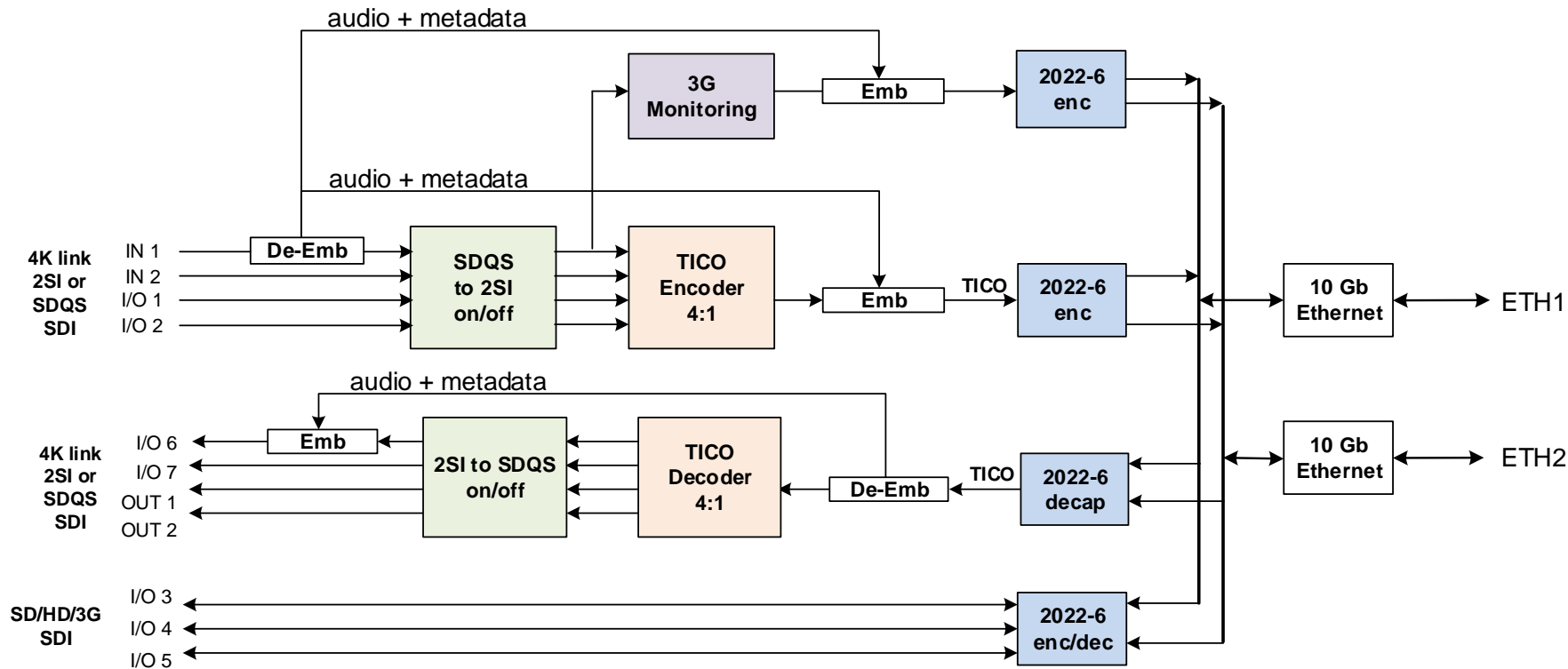
183 cards across 16 frames processing
643 multicasts

IP Gateways

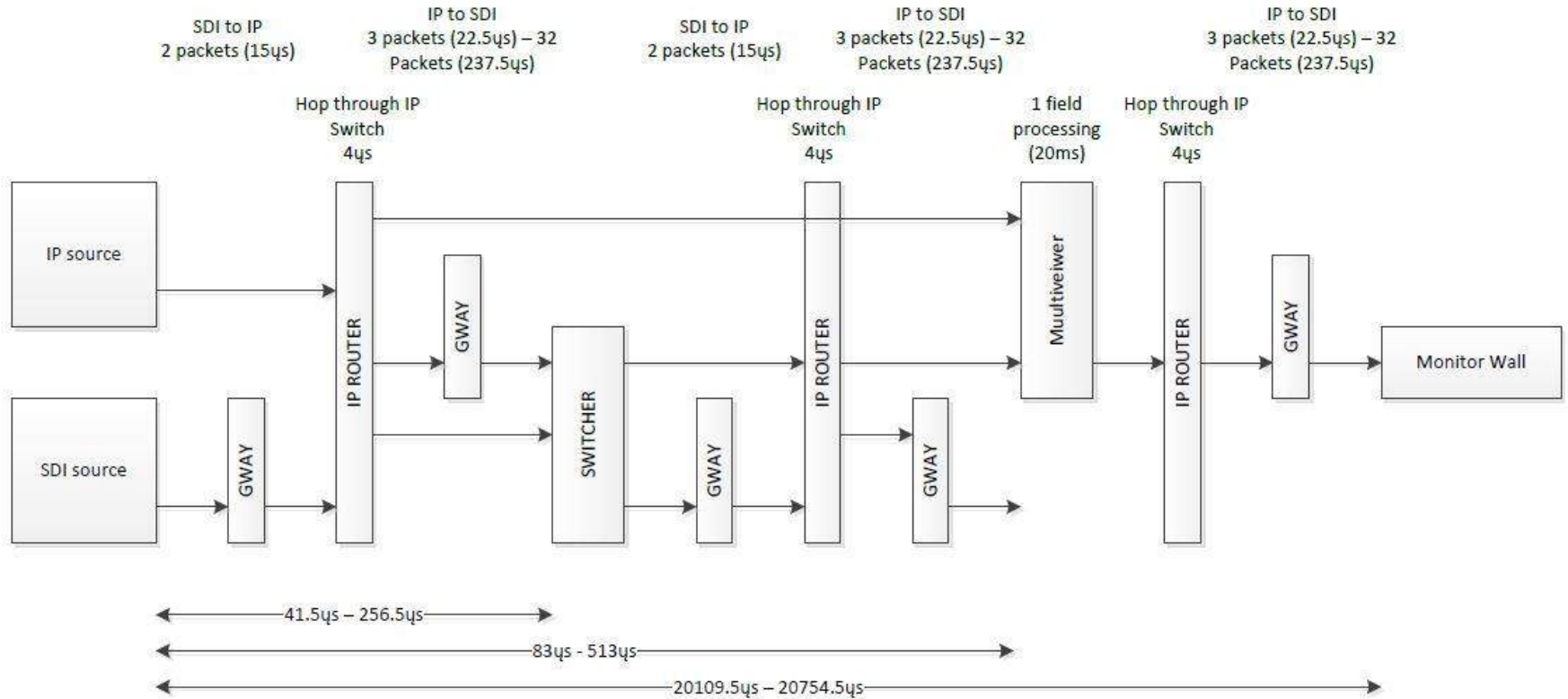


Function	IPG Cards	Multicasts	
		UHD	HD/SD
Camera	22	18	136
Replay	50	72	84
Switcher	28	56	0
Format Conversion	38	68	36
Transmission Infrastructure	14	24	18
Monitoring	22	21	66
External Links	9	14	34
Total	183	273	374

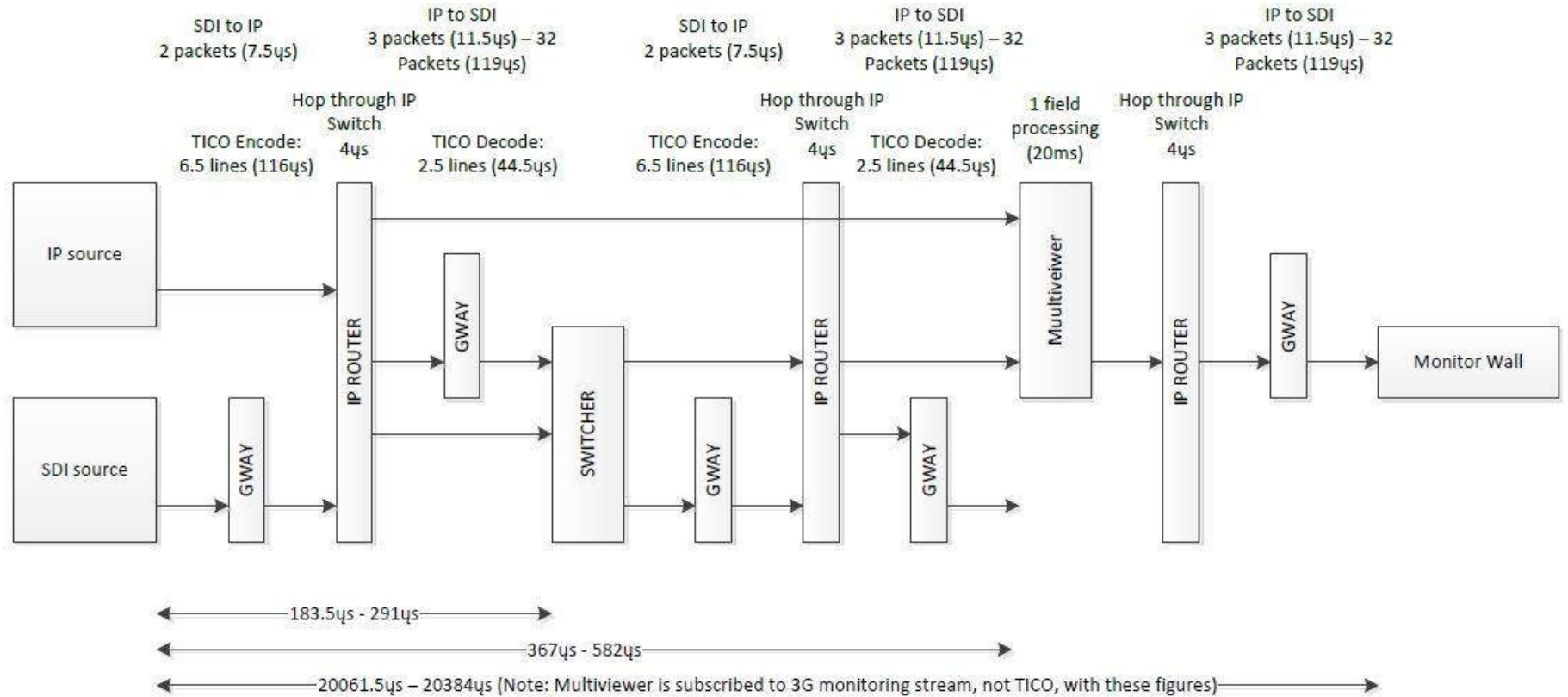
Gateway design for UHD over 1-wire



TIMING producing at HD 1080i50



TIMING at UHD with TICO



Expected IP Switch Performance

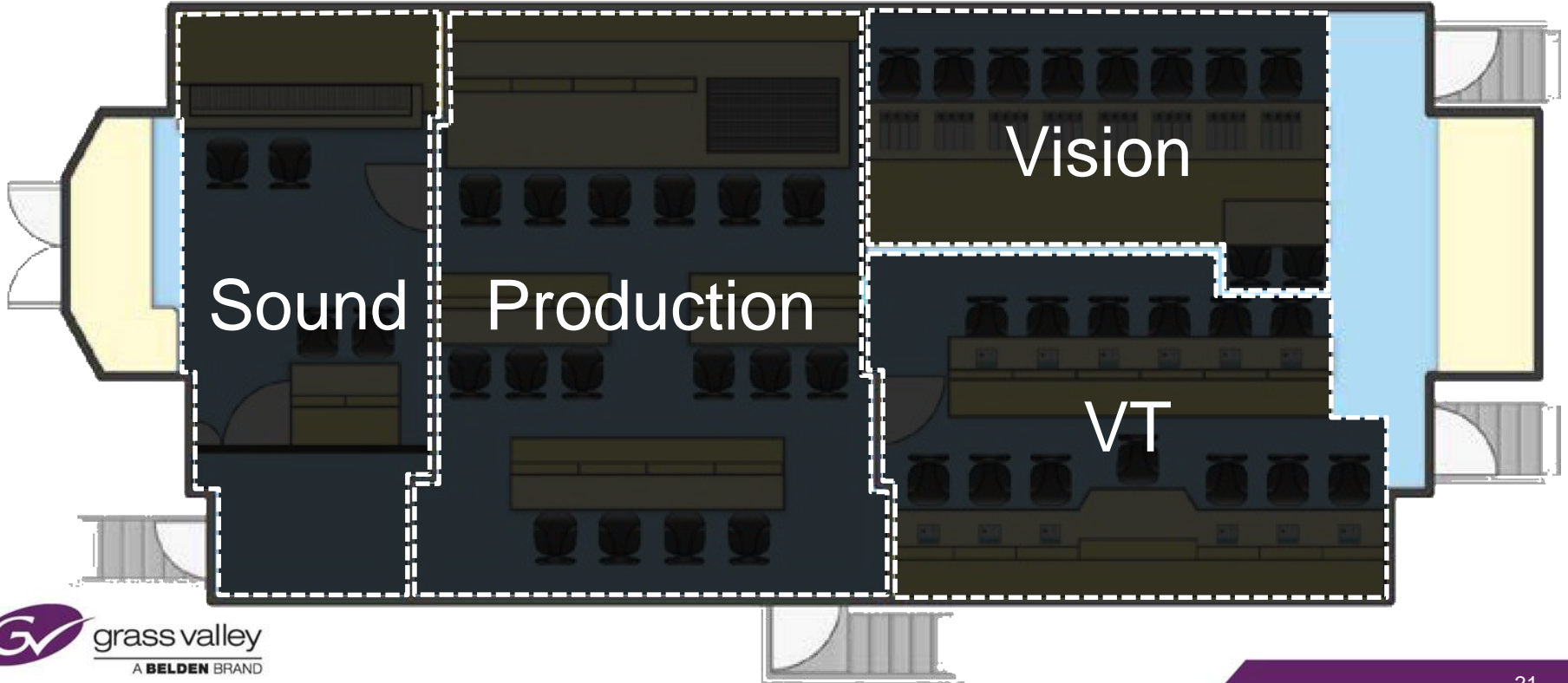
- ❖ Must be suitable for Broadcast Video applications
 - IGMPv2 and IGMPv3 (Internet Group Management Protocol) support
 - Single IGMP requests processed in less than 10 msec
 - A minimum of 150 multicast groups per 10GbE physical interface supported on the network switch (i.e. scaling accordingly for 40GbE)
 - Network switching with non-blocking wire-speed switching and forwarding performance
 - Every physical interface capable of simultaneously transmit & receive packets at maximum port speed (i.e. 1Gbps, 10Gbps, 40Gbps) without any degradation in performance (i.e. packet drop, additional jitter, additional port-to-port latency) regardless of packet size (i.e. up to 1500 bytes / no jumbo frames)
 - Separate dedicated control network required

Expected IP Switch Performance

- ❖ Cisco Nexus 9272Q Spine and Leaf Topology was chosen
 - Utilising Cisco's "non-blocking multicast" (NBM) algorithm which is specifically designed for professional media network solutions
- ❖ 40GbE AOC connectivity between the Spine and Leaf
 - 2.88Tbps of network bandwidth available in both directions
 - 40GbE Breakout Mode required (4 x 10GbE Lanes)
- ❖ End-point device connectivity requirements
 - 48 x 40GbE QSFP+ (GV Node / Multiviewers)
 - 230 x 10GbE SFP+ (IP Camera, Video Switcher and Gateway cards)
 - End-point devices distributed across leafs for redundancy

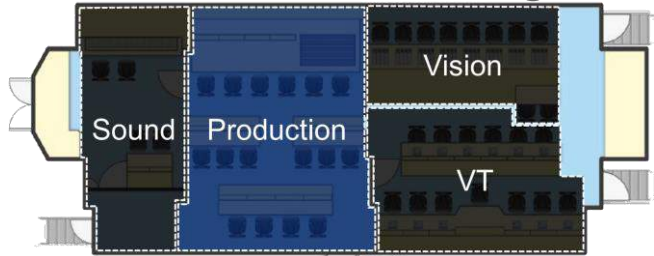
“IP” Core Topology - Multiviewer

- Multi-Viewer design had a significant impact



“IP” Core Topology - Multiviewer

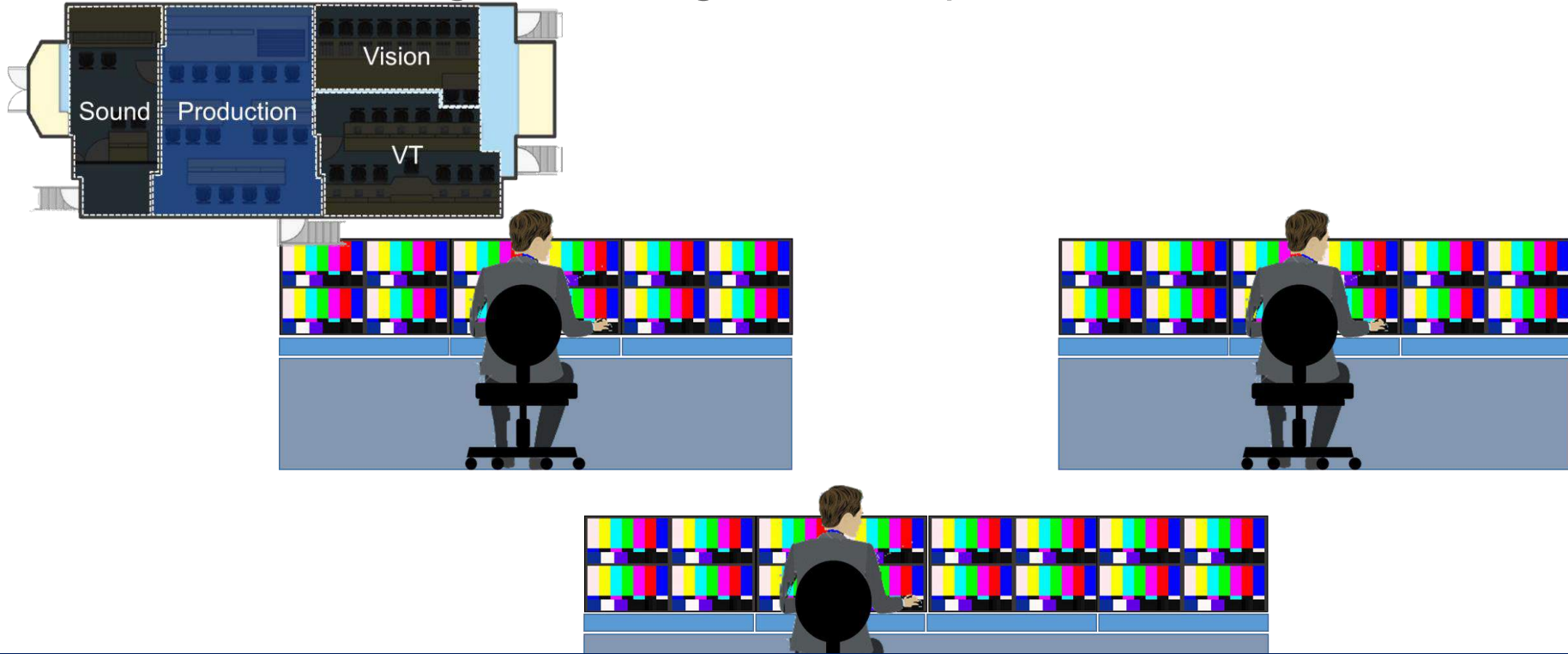
- Multi-Viewer design had a significant impact



Front Production: 172 sources X 16 displays

“IP” Core Topology - Multiviewer

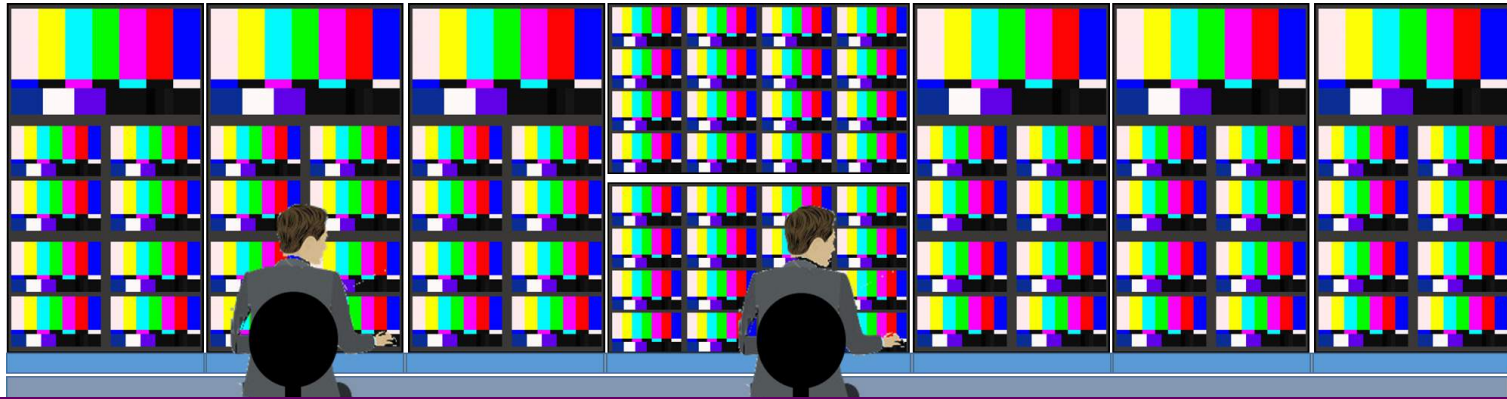
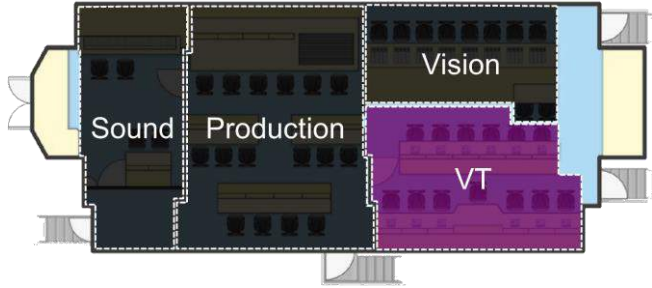
- Multi-Viewer design had a significant impact



Rear Production: 40 sources X 10 displays

“IP” Core Topology - Multiviewer

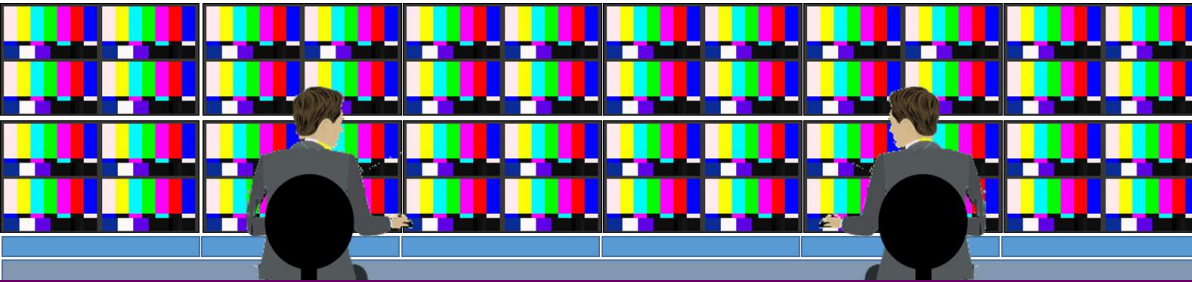
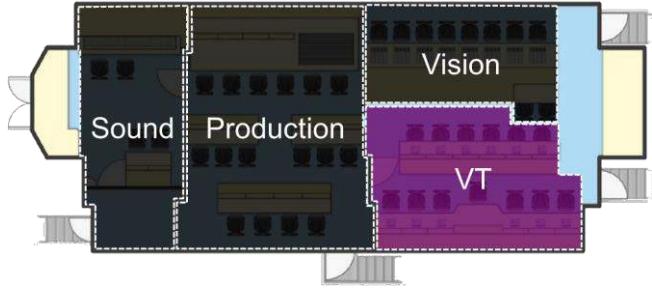
- Multi-Viewer design had a significant impact



Front VTR: 86 sources X 8 displays

“IP” Core Topology - Multiviewer

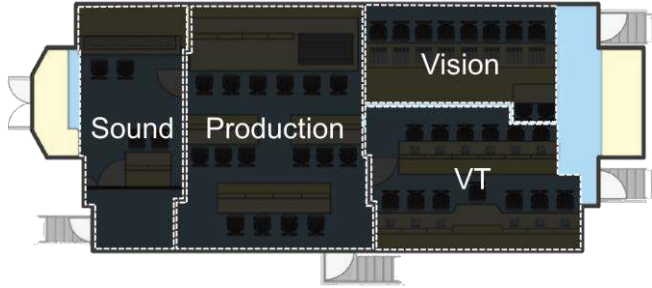
- Multi-Viewer design had a significant impact



Back VTR: 48 sources X 12 displays

“IP” Core Topology - Multiviewer

- Multi-Viewer design had a significant impact



Just the monitor wall needed routing of **488** multicast streams



Engineering: 62 sources X 10 displays

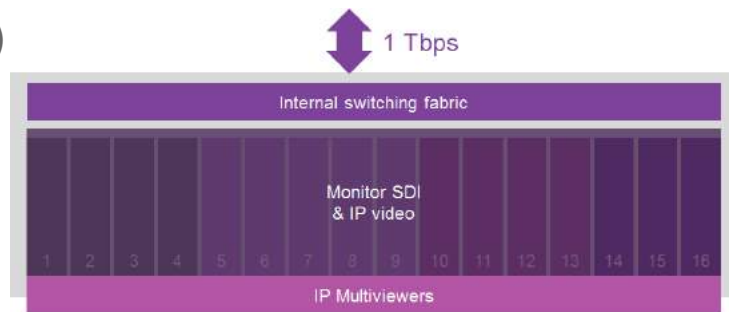
End-point Device – Routing + Multiviewer

❖ GV Node – KMX-4911 Multi-viewer Cards



❖ Operational Modes

- 16 x Card slots (SDI I/O & Multi-viewers)
 - 3G 1080p50 and HD 1080i50 (144 x 144)
- 12 x 40GbE QSFP+ Aggregation Ports
 - 3G 1080p50 and HD 1080i50 (144 x 144)



❖ Enhancements

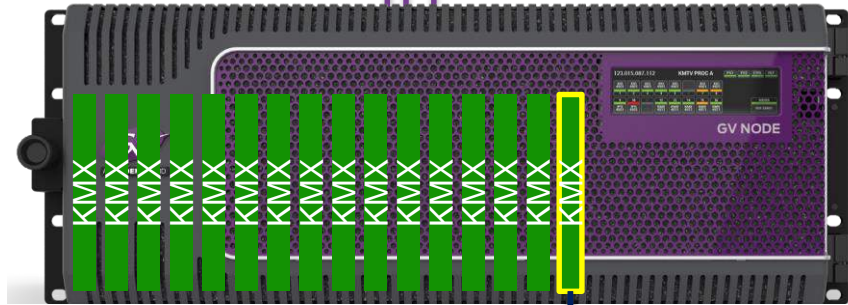
- 9x2, 18x2, 27x4 and 36x4 support
- SDI <> IP and IP <> IP - Vertically Accurate Switching

“IP” Core Topology

Network Switch
(1 of 4)



SMPTE 2022-6 IP
flows over
3 X 40GbE QSFP+

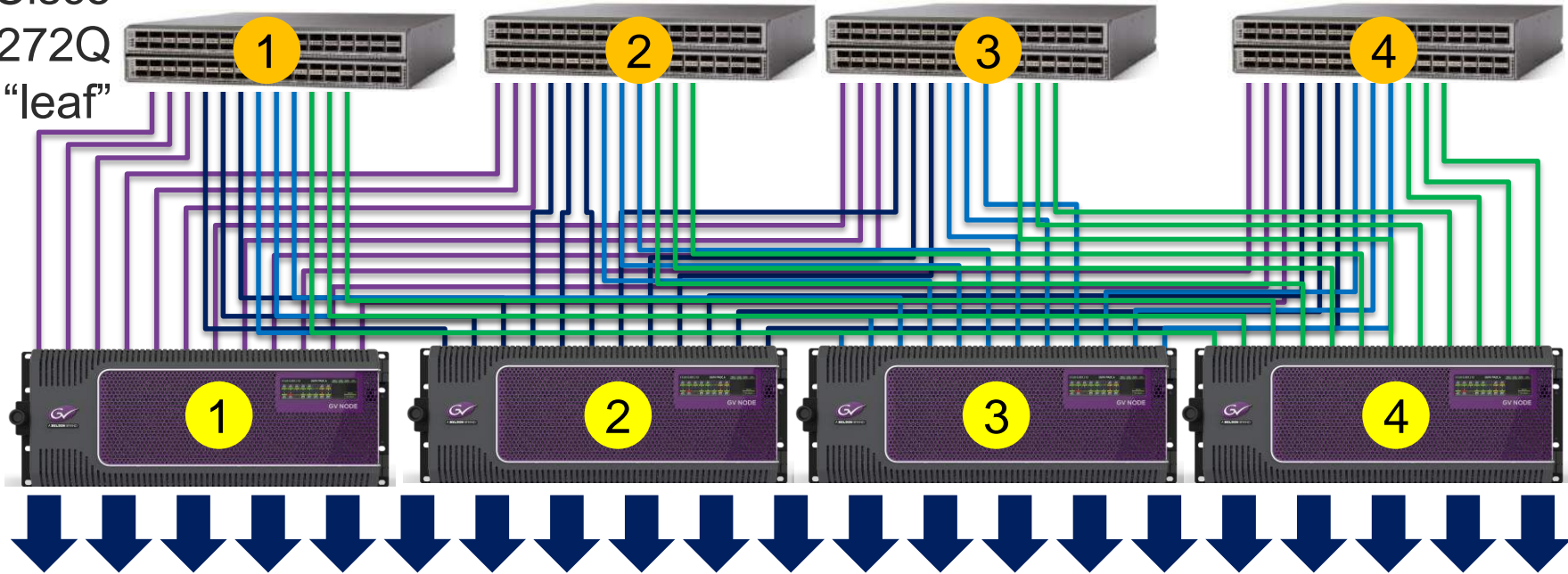


Multi-viewer Displays



“IP” Core Topology

Cisco
N9272Q
“leaf”



Feeding a total of 56 displays

“IP” Core Topology

Cisco N9272Q “Spine”

2.88 Tbps

18 X 40GbE
QSFP+

“Leafs”

1

2

3

4

GV
Node

1

2

3

4

57 x
10GbE SFP+

58 x
10GbE SFP+

57 x
10GbE SFP+

58 x
10GbE SFP+

IP Cameras



IP Production Switcher

SDI Equipment via IP
Gateways

Vertically Accurate Switching

- ❖ Distributed IP architecture around the OB truck
 - No singular monolithic core switching video router

- ❖ Vertically Accurate Switching was isolated to the areas of need:
 - Video Switcher (of course!)
 - Emergency Switching (in the event of switcher failure)
 - Camera “OCP” Touchdowns
 - Replay / VT Line Feeds
 - VT Guarantee Position

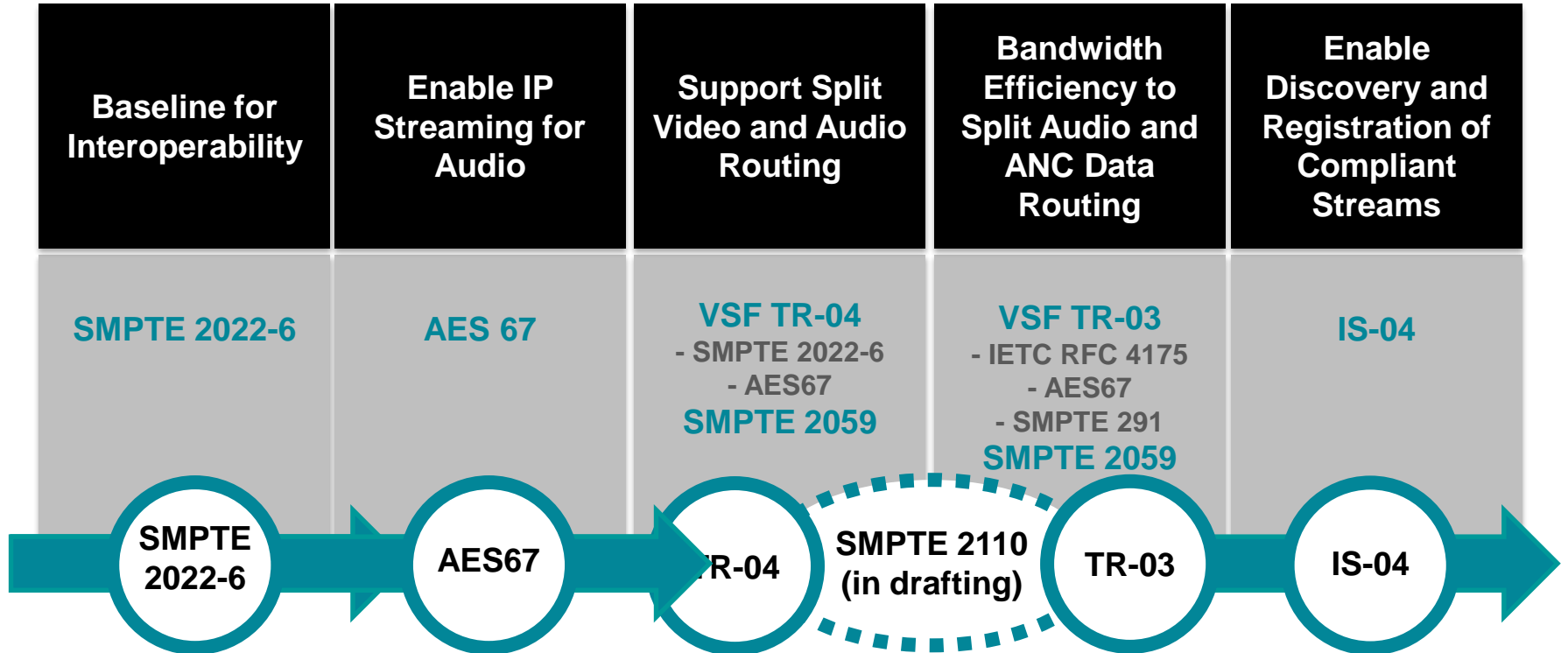




 DOLBY.ATMOS

What's Next?

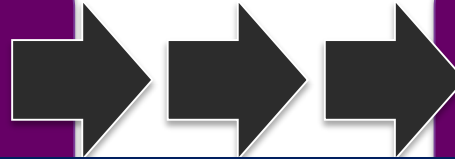
- Real-world Glass-to-Glass IP based solutions are here and ready to be deployed today, but technology and standards are also evolving:



What's Next?

- ❖ Evolution in the management of flows, individual essences will impact network design considerations

- Fixed flow size
- Non-Blocking Multicast
- Deterministic Latency
- Single spine
- Limited set of router models



Mostly
Software
Evolution

- Variable flow sizes
- Per flow bandwidth provisioning
- Multi-spine expansion
- Extended set of router models



Vidtrans 2017



InterOps

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Technologies Demonstrated

Draft SMPTE ST-2110 - 10/20/30
IP Ancillary Data
SMPTE ST-2059 Timing
SMPTE ST-2022-7 Protection Switching
AMWA IS-04 NMOS Discovery & Registration

Participating Companies

Arista Networks
COBALT DIGITAL
COVELOZ Technologies, Inc.
Evertz
Grass Valley, a Belden Brand
Imagine Communications
Macnica
Mellanox Technologies, Inc.
Nevion
Ross Video
SAM - Snell Advanced Media
Sony Corporation

Support

EBU
Fox
IRT
PacketStorm Communications
Video Clarity

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Thank you!

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