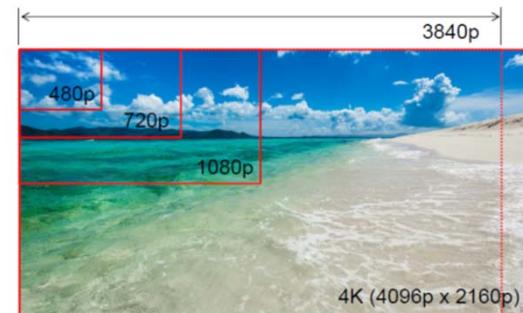


What is 4K and how do I transmit it?

David Stephens, CTS
Belden
Strategic Account Manager
Broadcast and Audio Video Group

As a basis, what is 4K?

- **Display Resolution = # of vertical pixels.**
 - HDTV = 1080, 4K/UDH= 2160
- **Aspect ratio, Width:Height.**
 - Used to be 4:3, now is 16:9 (4K/UHD) and 17:9 for “full” 4K



Source: <http://www.technologytell.com/digital-photography/245/widescreen-vs-standard-screen/>

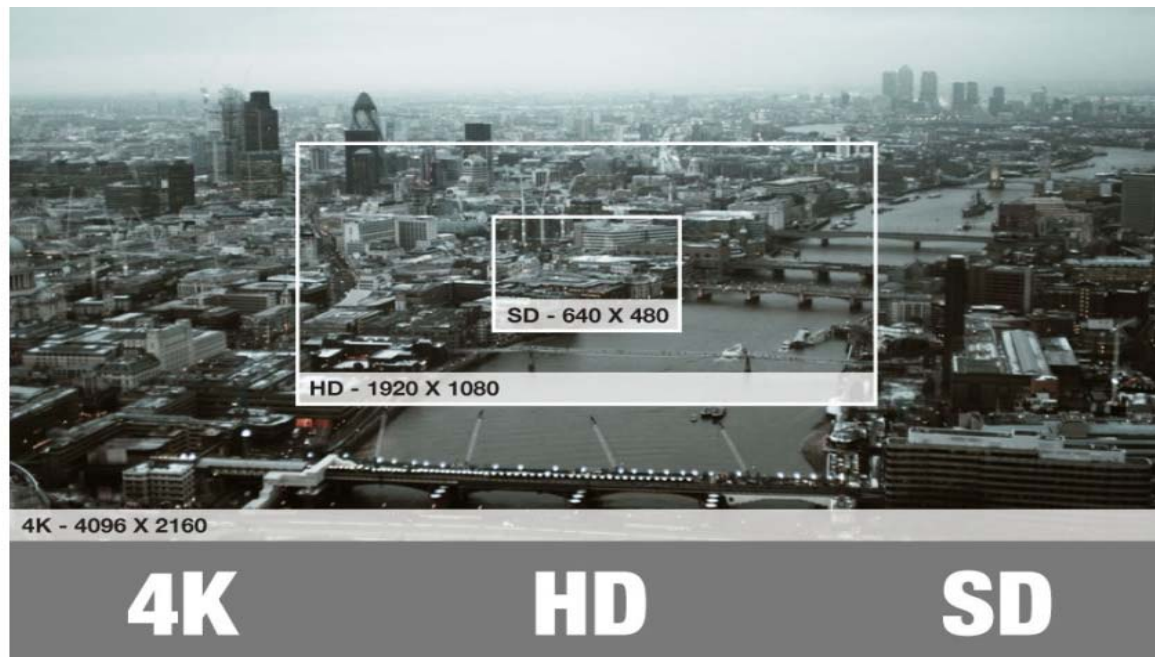


2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

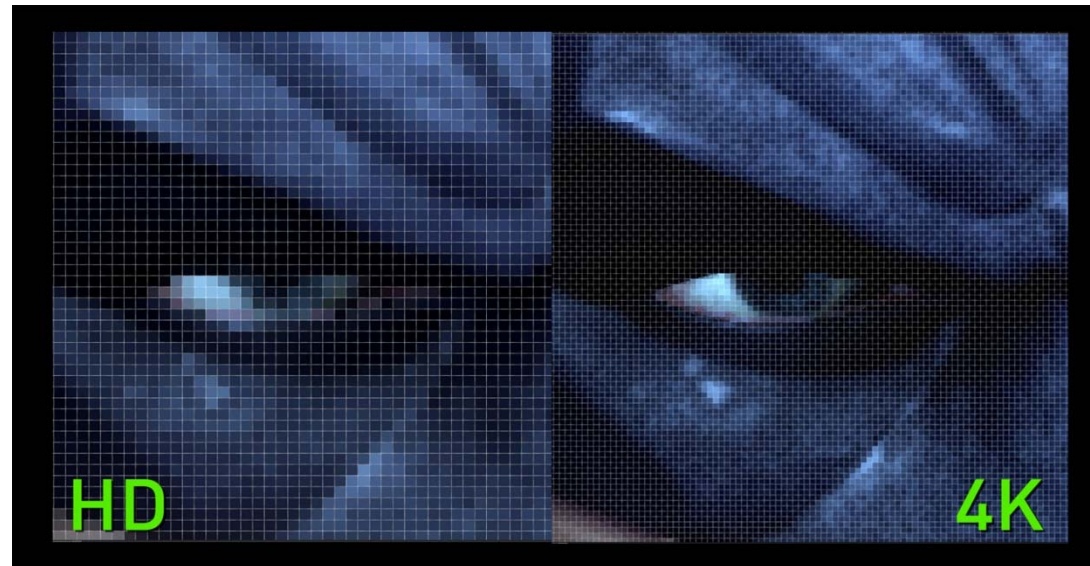
BICSI

4K – Field of View



Source: <http://dennismancino.blogspot.ca/2015/07/how-4k-surveillance-should-change.html>

4K – Pixel Resolution



Source: <http://4k.com/resolution/>



2019 BICSI Winter Conference & Exhibition

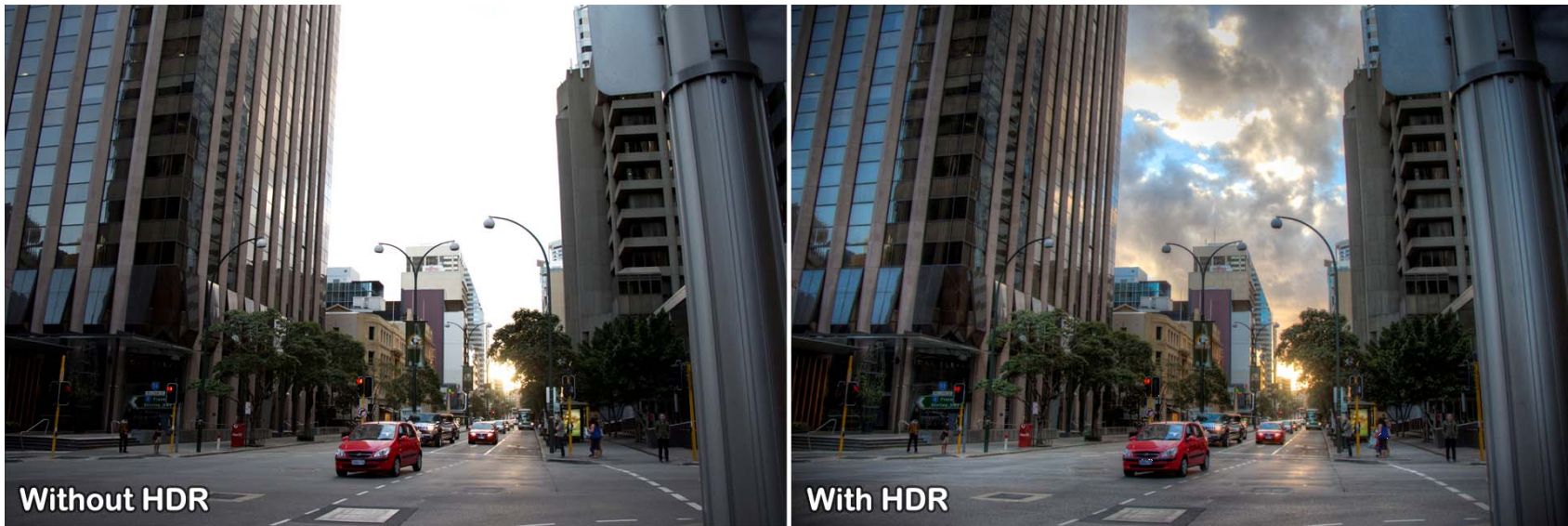
January 20-24 • Orlando, FL, USA

BICSI

Important factors in our 4K world, HDR and Color Depth

- High Dynamic Range
 - Dynamic Range indicates the difference between the brightest and darkest parts of a scene.
 - Luminance is how bright an object appears
 - the SI unit for luminance is candela per square metre (cd/m²), commonly referred to as a nit
 - the human eye is capable of perceiving luminance levels of between 0.000001 nit (10⁻⁶) and 100 million nits (10⁸) but current broadcast and consumer standards (SDR) limit black levels to 0.1 nit and peak white to 100 nits, HDR changes that to 0.0005 to 10000 nits as show in the next slide.

An example of the effect of HDR



Source <https://www.gamefaqs.com/boards/691087-playstation-4/74265743>

4K Color standards

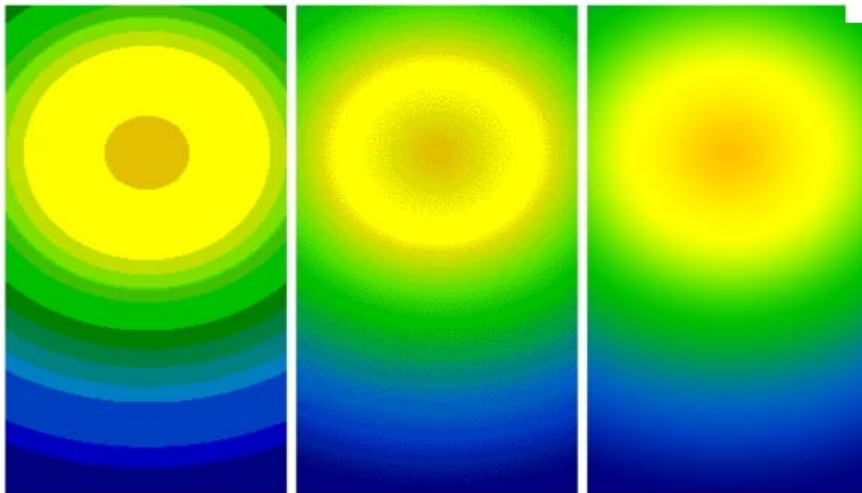
- Color Bit Depth(30, 36, 48 is also called Deep Color, WCG, Dolby Color, etc)

| Bit Depth | Bits Per Color | Max Values Per Color | Max Total Colors |
|-----------|----------------|----------------------|------------------|
| 24 | 8-bit | 0 - 256 | 16.78 Million |
| 30 | 10-bit | 0 - 1024 | 1.1 Billion |
| 36 | 12-bit | 0 - 4096 | 68.7 Billion |
| 48 | 16-bit | 0 – 65,536 | 281.5 Trillion |

Note – The human eye can see up to 7-10 million colors

Judd, Deane B.; Wyszecki, Günter (1975). *Color in Business, Science and Industry*.
Wiley Series in Pure and Applied Optics (3rd ed.). New York: [Wiley-Interscience](#). p. 388.

4K Color standards

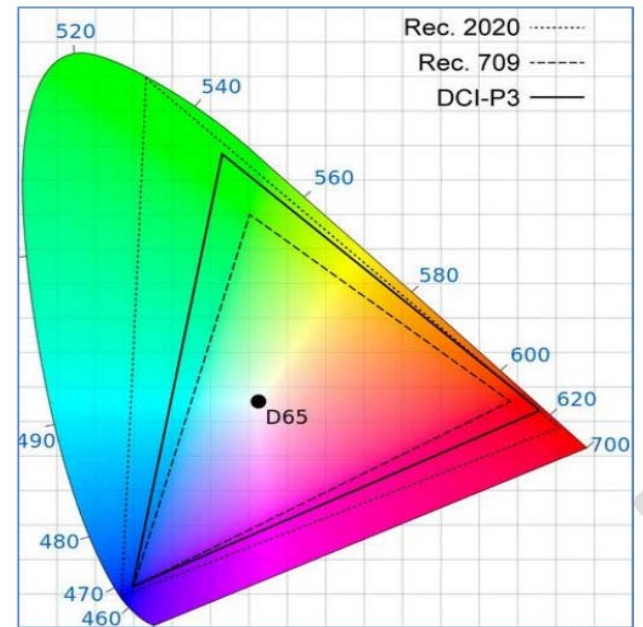


Left: color bit depth 12 bits (via Rec.2020).

Center: color bit depth 10 bits (via Rec.2020).

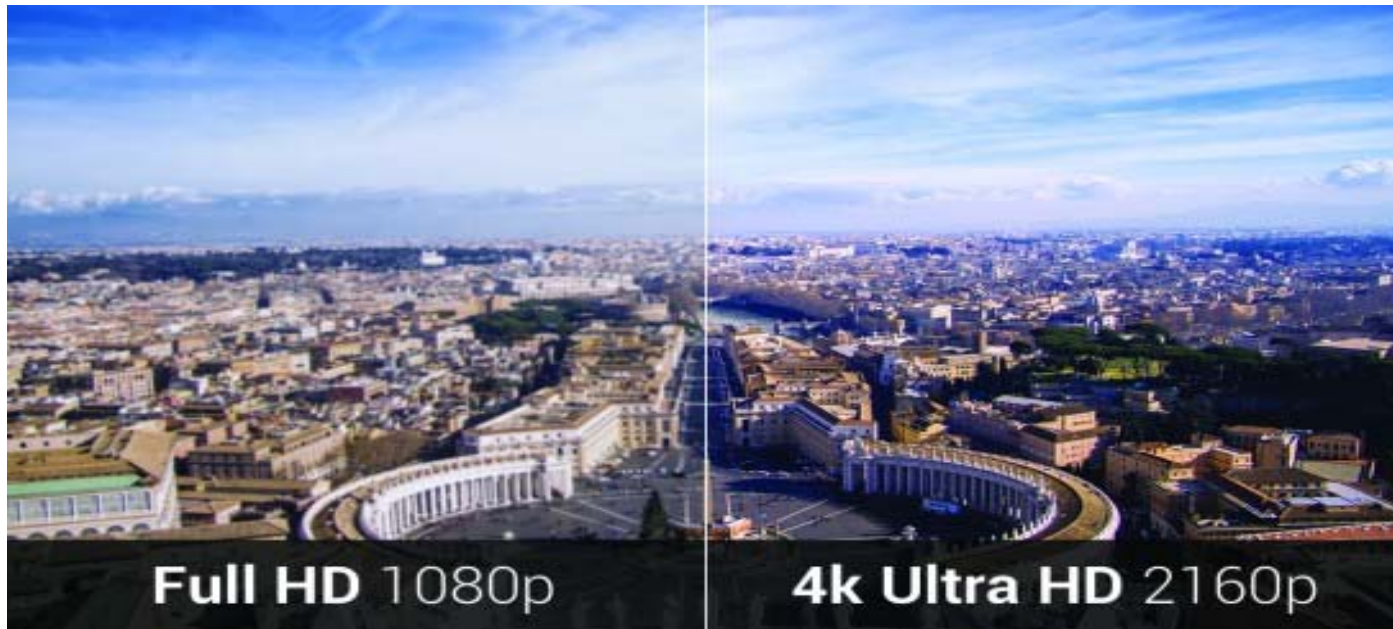
Right: color bit depth 8bits (via Rec. 709).

source: http://forum.hardware.fr/hfr/VideoSon/HiFi-HomeCinema/unique-haute-definition-sujet_141366_1.htm



Source <http://www.acousticfrontiers.com/uhd-101-v2/>

4K Color Depth and Resolution



8 bit color

10 bit color

Source: http://www.pinsdaddy.com/4k-comparison_h8cfilQ7ah6k6y*1f23NKZFZgDPK0K2tvR%7Cu23ynOK0/



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

So what is the camera capturing?

- For Broadcast, Green Valley (a Belden company) makes a camera line, LDX, that supports HDR and 10bit color. This is what is normally captured today in Broadcast venues.
- Digital Cinema movie makers are normally capturing 16, 24 or 48 bit color. This allows them a greater amount of control of their product.

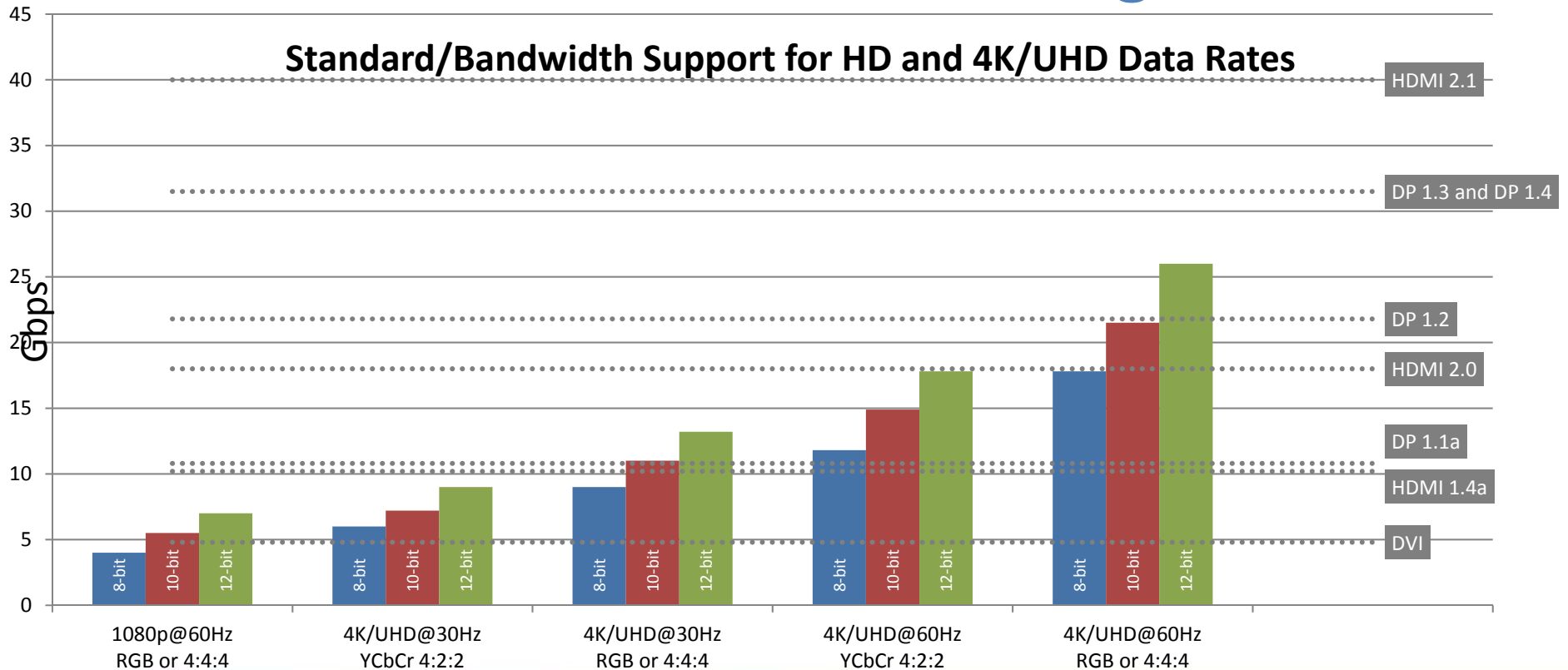


2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

4K – Bandwidth Challenges



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA



So how can I deliver these 4K signals?

- Coax – 4K UHD Coax delivers 12G SDI
- HDMI 2.0 – up to 18Gbps, short distances
- AOCs extend the distances for HDMI
- SDVoE – 4K uncompressed/lightly compressed
- HDBaseT - extends uncompressed video (up to 4K) and audio, control signals like CEC and IR, USB 2.0, 100Mbits Ethernet, and POH (100 watts)



4K UHD Coax & Connectors for 12G-SDI

What is it?

- 1st coax cable line designed for 12G-SDI
 - Higher bandwidth needed for 4K
- 12 GHz BNC connectors: 1-piece & 3-piece

Benefits:

- Allows broadcasters flexibility to upgrade to IP at own pace
- Saves installation time, money & space compared to dual- or quad-link configurations
- Reliable for Mission Critical application – Belden trusted brand



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

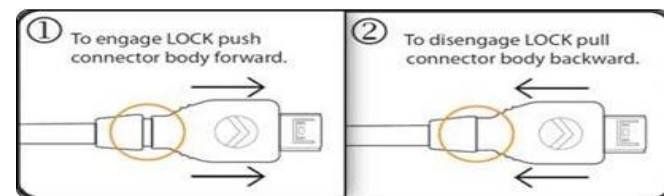
Recommendations for Coax

- Belden recommends our 12G-SDI coax cables for 4K solutions, supporting the SMPTE 2082 (12G) and 2081 (6G) standards.
- These coaxes guarantee a 15dB return loss limit.
- They have a custom drawn solid silver-plated copper conductor.
- Maximum distances run from 45m for 4855R to 78m for 4694R and 117m for 4731R.



HDMI 2.0

- Use High Speed HDMI or High Speed with Ethernet cables capable of 1080p, 4K, 3D, Deep Color (Always check manufacturer specs for resolution/distance)
- Cable length is limited to 15 m due to attenuation, 10-15 m cables can be made with thicker conductors, which are heavier and less flexible
- Manufacturers have introduced gripping/locking connectors to secure the cables for the commercial space



HDMI versions

| Version | 1, 1.1, 1.2 | 1.3 | 1.4 | 2.0 | 2.1 (Jan 2017) |
|------------------------|-----------------|-----------------|---|-----------------------|-----------------------------------|
| Pixel clock rate (MHz) | 165 | 340 | 340 | 600 | ? |
| Bandwith (Gbps) | 4.95 | 4.95 | 10.2 | 18 | 48 (new cable) |
| Color depth (bit/px) | 24 | 48 | 48 | 48 | 48 |
| Max resolution | 1920x1200/60 Hz | 2560x1600/60 Hz | 3840x2160 /30 Hz (UHD) 4096x2160/ 24 Hz (4K) | 4096x2160/ 60 Hz (4K) | 8K / 60 Hz 4K / 120 Hz |

All versions have 36.9 Mbps of audio
Ethernet Channel and ARC only after 1.4

HDMI 2.1

- HDMI 2.1 – new specification is published
 - Higher video resolutions support a range of high resolutions and faster refresh rates including 8K60Hz and 4K120Hz for immersive viewing and smooth fast-action detail. Resolutions up to 10K are also supported for commercial AV, and industrial and specialty usages
 - Dynamic HDR support ensures every moment of a video is displayed at its ideal values for depth, detail, brightness, contrast and wider color gamuts—on a scene-by-scene or even a frame-by-frame basis
 - The Ultra High Speed HDMI Cable supports the 48G bandwidth for uncompressed HDMI 2.1 feature support. The cable also features very low EMI emission and is backwards compatible with earlier versions of the HDMI Specification and can be used with existing HDMI devices
 - eARC simplifies connectivity, provides greater ease of use, and supports the most advanced audio formats and highest audio quality. It ensures full compatibility between audio devices and upcoming HDMI 2.1 products.



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

Recommendations for HDMI's

- Belden supports HDMI 2.0 Standard
 - Supports UltraHD and 4k at 50/60 (2160p)
 - Audio sampling frequency of up to 1536kHz for exceptional audio clarity
- Standard connectors (**available with locking mechanism**), Mini & Micro
- Available in lengths up to 65ft (longer distances possible via active cables or HDBaseT)
- Assemblies over 5 meters (16 ft.) are active and directional
 - Smaller, more flexible cable for easier installation
 - 36mm reduced depth connector (up to 10% smaller than competition)



x

AOCs – Active Optical HDMI Cables

- High Speed Active Optical HDMI Cable is an ideal solution for running 4K UHD HDMI 2.0 signals, 4K@60Hz (4:4:4) UHD, over long distances up to 100 meters (328 ft). High Speed Active Optical cables are thinner, lighter and more flexible than copper or even standard optical cables while providing transparent EDID, HDCP and HDR support without signal attenuation and also provide reduced risk of EMI and RFI interference which provides a perfect solution for critical AV installations that demand the highest signal integrity.

AOCs – Active Optical HDMI cables

Fast & Easy Installation

- Active Optical HDMI cables have a smaller diameter, and are more flexible compared to copper based HDMI solutions and is easier to bend and fit into small spaces
- Reduced risk of EMI and RFI interference which provides a perfect solution for critical AV installations that demand the highest signal integrity
Detachable HDMI ends and pulling capsule allow for easier pulling through conduit and other tight spaces
- Fewer potential failure points when compared to installs with HDMI extenders
- No external power source required for runs up to 100 meters (328 feet) - .75W max power consumption



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA



AOCs – Active Optical HDMI cables

Performance Strengths:

- Designed to withstand rigors of installation, reducing the potential for damage by the installer
- Non-Slip HDMI connector with 15 lbs. of restraining force reduces potential for accidental disconnection
- Supports video resolutions of 4K@60Hz 4:2:0 UHD, 4K@30Hz 4:4:4 8Bit, full HD, 3D Deep Color across all lengths and is tested to one pixel error per billion
- Reduced installation time and overall project costs



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

SDVoE - Software-defined Video over Ethernet

Mission statement

The SDVoE Alliance is a non-profit consortium of technology providers collaborating to **standardize** the adoption of **Ethernet** to transport AV signals, and to create a **platform** allowing software to define AV applications.

1/21/2019



What is SDVoE?

- A complete ecosystem
- Matrix switch performance & simplicity
- Advanced AV processing
- AV over IP flexibility
- An interoperable standard

November 2018:

- 40 member companies
- 158 SDVoE-based products
- 251 certified design partners



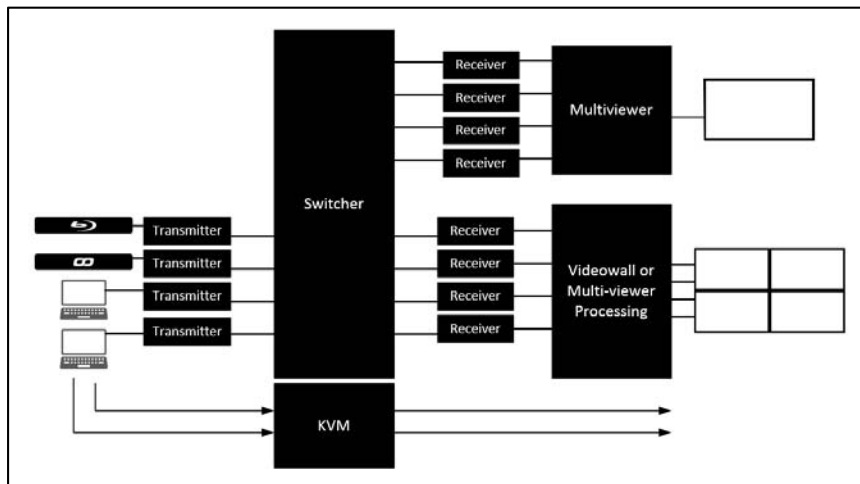
2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

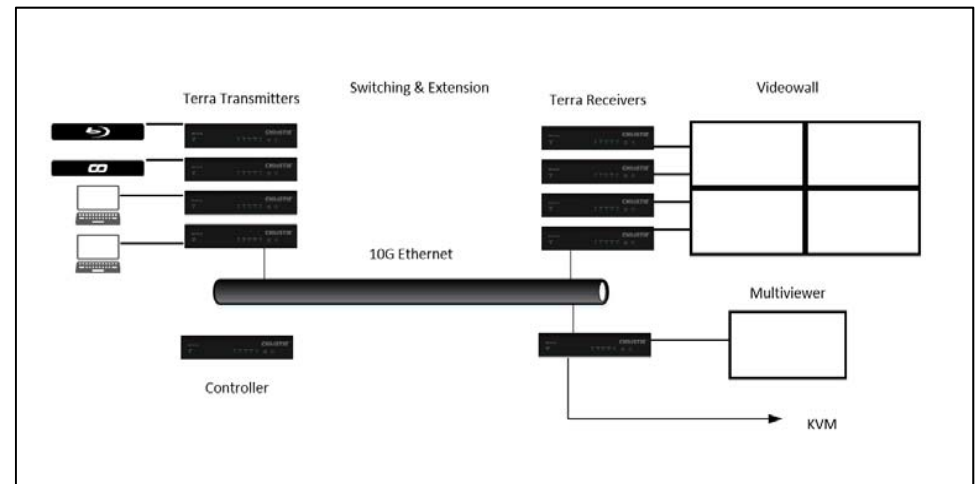
BICSI

Two products and simple, efficient designs

Traditional Approach



Efficient & Cost Effective SDVoE



1/24
1/21/2019

2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

SDVoE - 40 members and accelerating growth



SDVoE Alliance goals

- Displace point to point extension as the market's most common technology
- Drive standardization in the AV signal management space
- Provide all of the education and tools necessary

- 1/21/2019



SDVoE - a solution for matrix switching and AV over IP

- SDVoE offers the ease of use and performance of a matrix switch
- SDVoE offers the scalability and flexibility of AV over IP
- A software-defined AV system meets today's business needs, and adjusts to meet tomorrow's

1/21/2019

Minimal compression, deployed only when required

1080p60 or 4K30 sent uncompressed

4K60 compressed by 25%

1G 'data lane' always leftover

Sub-millisecond latency

Routable over IP or matrix backplane

Integrated AV processing



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

SDVoE Academy

Free online education and certification

- Originated with successful SDVoE Design Partner training
 - Over 200 certified to date
- Learning tracks for system design, network config, troubleshooting, and selling AV over IP with SDVoE
- Brand-agnostic way for AV pros to differentiate in the AV over IP space



SDVoE[™]
A C A D E M Y



<http://academy.sdvoe.org>

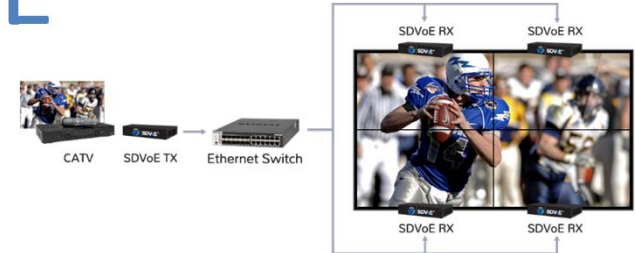
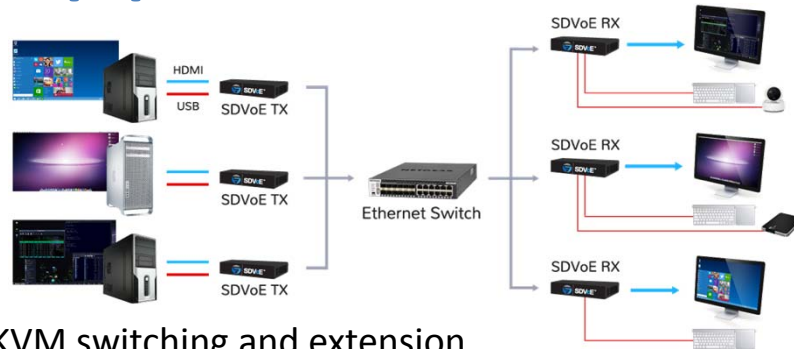
2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

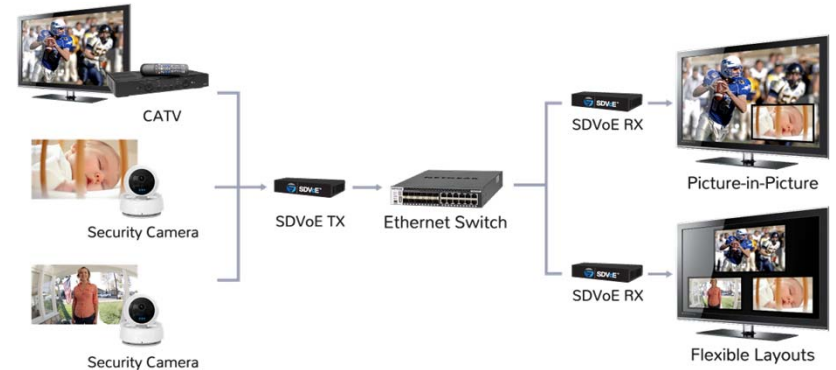
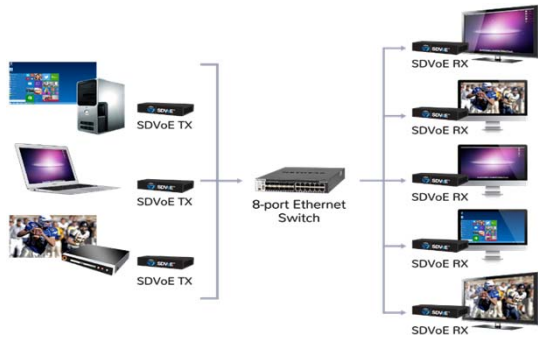
BICSI

Applications for SDVoE

Video wall management



AV and KVM switching and extension



... or any combination at any time

SDVoE transport modes - Genlock

- Decoder output is fully synchronized with encoder input
 - Therefore multiple decoders can be synchronized to one another
- Maximum latency 0.1 ms
 - Varies by format
- Signal is output 'as is' regardless of format
 - Any HDMI 2.0b signal
 - HDR10, HDR10+, DolbyVision
 - DTS-MA, Dolby Atmos
- Use cases – critical viewing
 - Image mastering
 - Cinema
 - Medical – digital operating room
 - Live staging and events



SDVoE transport modes – Quick Scaling

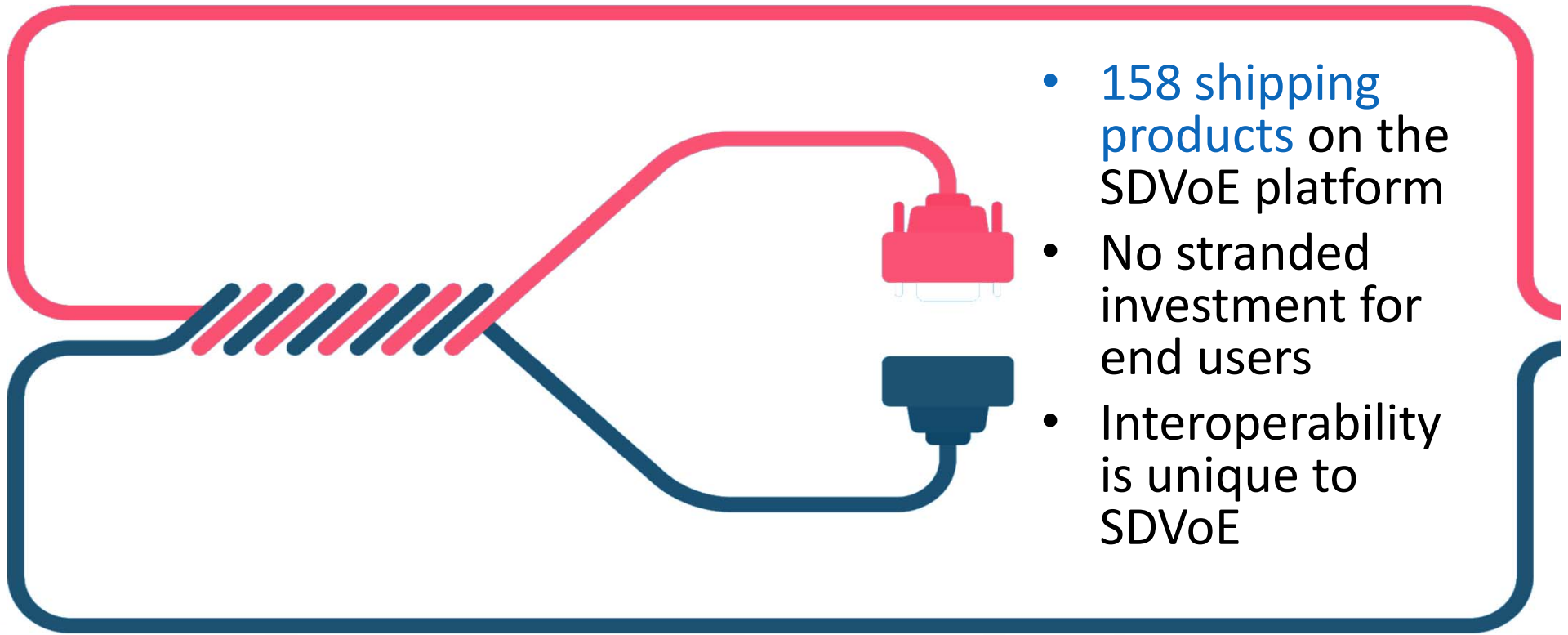
- Industry's lowest-latency scaling capability
 - No frame buffer penalty
- Maximum latency 3ms
- Output is time-locked to input signal
 - Outputs synchronized even with scaling
- Format scaling for display compatibility
 - Example: 2160p to 1080p
 - Frame rate conversion not possible
- Can be combined with video wall processing
 - Because of synchronization, no tearing between video wall screens
- Use cases – low latency required
 - Areas where scaling is demanded but latency still at a premium
 - Sports stadiums
 - Medical – digital operating rooms
 - High quality video walls without tearing

SDVoE transport modes – Full Processing

- Scaler with frame buffer enables complete processing system
 - Arbitrary scaling with frame rate conversion
 - Instant source switching
 - Multi-image compositing
- Maximum latency 2 frames
 - Frame buffer FIFO time
- Use cases – sophisticated processing
 - Video tiling and compositing
 - Multi-input video walls
 - Presentation switching



Unique to SDVoE: Interoperability



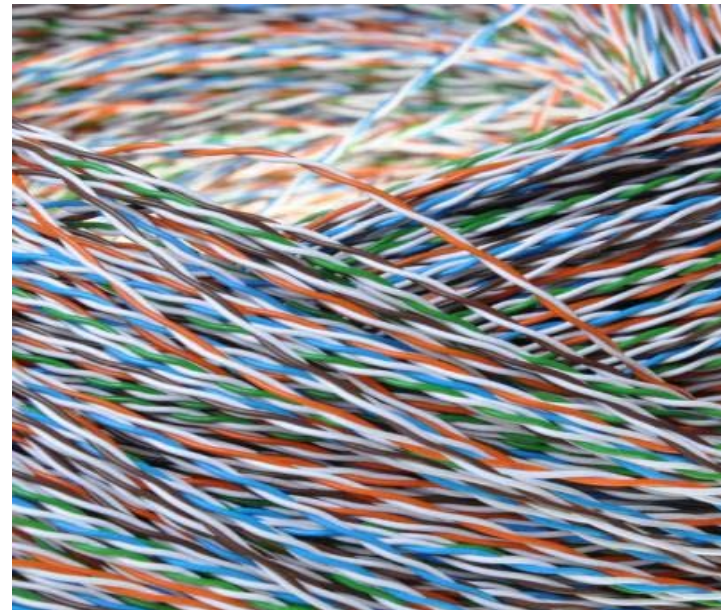
2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA



SDVoE - Convergence will never happen at 1 Gbps

- We have been promised AV/IT convergence for years
- No one seems to know when
- Control moved to Ethernet two decades ago
- Audio has moved to Ethernet (quickly!) in the last 5 years
- Video over Ethernet: most solutions require performance compromise



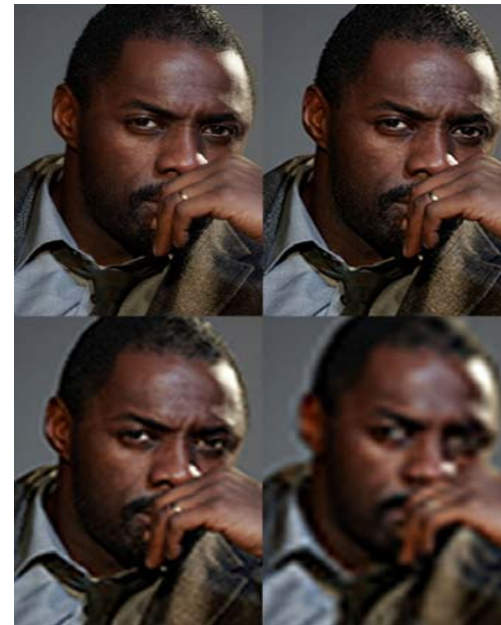
2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

SDVoE - 1 Gbps networks versus 10 Gbps networks

- 1 Gbps means tons of compression
- Pro AV demands high performance
 - Zero latency
 - Flawless image quality
- Anyone claiming 12-to-1 compression without latency needs to be highly scrutinized.
- Use 10 Gbps networks with SDVoe and make it work!



2019 BICSI Winter Conference & Exhibition

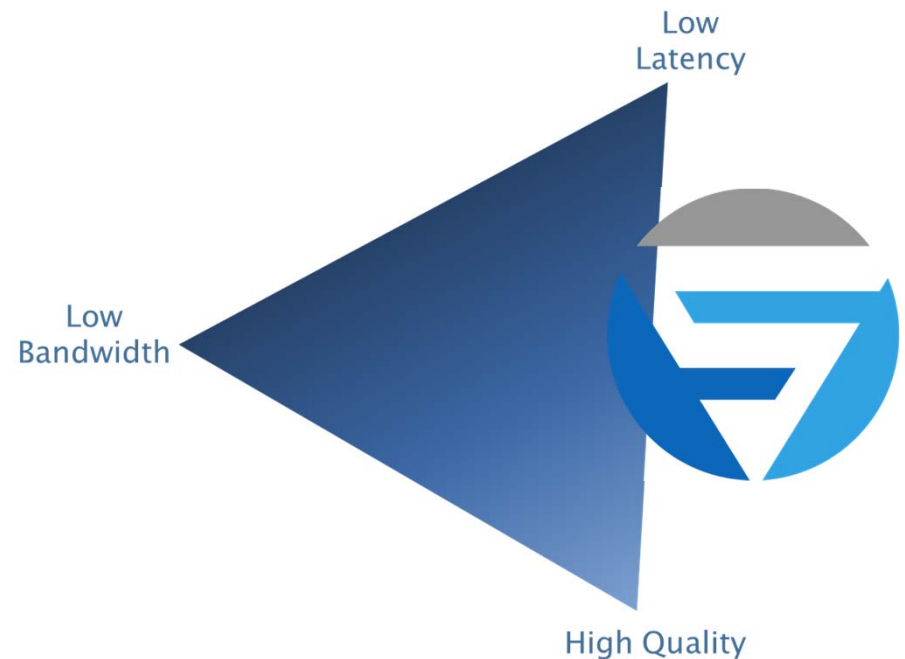
January 20-24 • Orlando, FL, USA

BICSI

SDVoE - Compromise bandwidth, not

experience!
SDVoE's pixel pipeline is an excellent choice for pro AV signal management

- Performance demands:
 - Zero latency
 - Flawless image quality
- Video quality demands are going up, not down
- Latency is literally your time
 - You are wasting your life waiting for that mouse pointer to move!
- Bandwidth is cheap *and getting cheaper!*



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

SDVoE – is shielding needed?

- SDVoE's stance is simple -- we didn't invent our own physical layer. The IEEE (supported by TIA/EIA) did. So, 10GBaseT requires CAT6, CAT6A, or better. It doesn't make any statement about whether it has to be shielded -- so it doesn't have to be. What it does need is proper installation technique.
- And if you get to choose your infrastructure, picking a shielded cable gives you extra peace of mind, and extra margin for error in your installation. But it's not required!



Recommendations for SDVoE



- We recommend using a Category 6A UTP cabling system as the **preferred category cable** for AV networks to transmit SDVoE video immediately or in the future.

- *Belden IBDN 10GXS and 10GX Field-Terminated or Pre-Terminated Cabling Systems*



- A Category 6A F/UTP shielded system can be considered as an **alternate** choice to transmit SDVoE video.

- *Belden IBDN 10GX Field-Terminated or Pre-Terminated Shielded Cabling System*

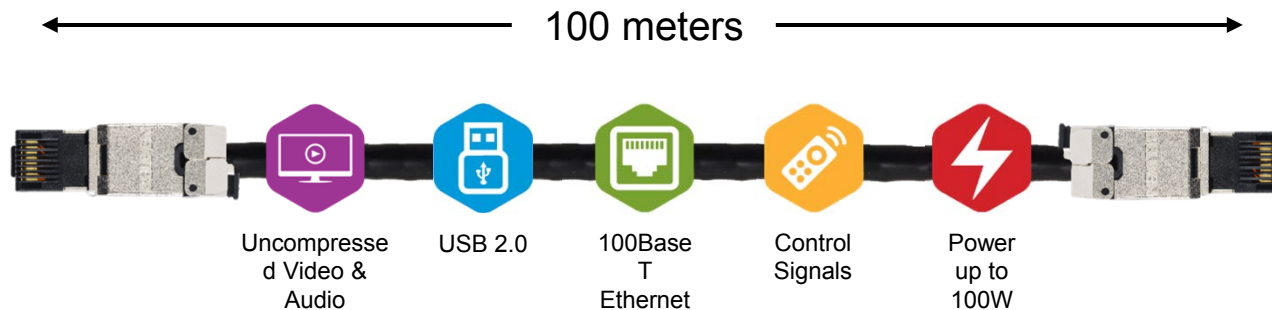


2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

What is HDBaseT?



5 Play™

Uncompressed Video & Audio, USB 2.0, Ethernet, Control, and Power



5Play, HDBaseT, the HDBaseT Alliance logo are trademarks of the HDBaseT Alliance.

2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA



HDBaseT

- IEEE proposed standard (1911.1, 2 and 3)
- Uses 4 twisted-pair cable to deliver 5 play up to 100 mts (the Alliance just announced HDBaseT over IP using fiber):
 1. Uncompressed High Definition Video and Audio
 2. USB 2.0
 3. 100 Mbps Ethernet
 4. Control signals : RS232, IR
 5. Power over HDBaseT (PoH) up to 100 W



2019 BICSI Winter Conference & Exhibition

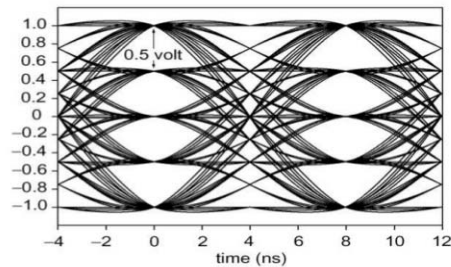
January 20-24 • Orlando, FL, USA



HDBaseT – How does it do it?

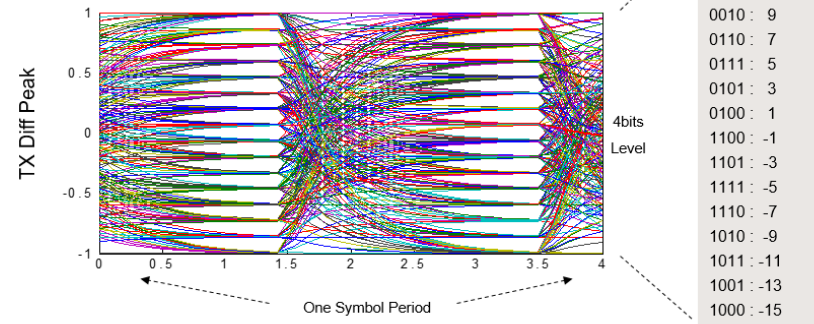
- HDBaseT used PAM16 (Pulse Amplitude Modulation 16, also used for 10G Ethernet), which creates a complex eye pattern, very sensitive to noise and/or interference

- Eye pattern for 5-level PAM (PAM-5), as used to operate gigabit Ethernet over 4 unshielded twisted pairs:



Source: <https://www.slideshare.net/ahad523/digital-communications-systems>

HDBaseT uses PAM16 - each symbol is transmitted using one of 16 discrete, differential voltage levels = 2^4 symbols



PAM16 TX Eye Pattern

Source: HDBaseT Alliance

HDBaseT – Factors to consider

- Factors to consider when selecting the cable for HDBaseT
 - Since we are using 4 twisted-pair cable on a TIA 568-C channel, we start by looking for category cables
 - The eye pattern of a PAM16 modulated signal is complex and very sensitive to noise, suggesting a shielded cable
 - 95% of the HDBaseT signal is under 450 MHz, suggesting the need for a Cat 6A cable or higher
 - The cables, in most practical applications, will be bundled in the pathways coming out of the media room, indicating that Alien Cross-Talk will be an issue. **Initial installs with bundles in North America, were made with Cat5e UTP and failed to transmit the signal at relatively short distances (Belden testing confirmed this).**
 - Which market is the cable for, residential or commercial?
 - What is the bandwidth of the signal? (4K/UHD vs HD 1080p)?
 - **You must prevent the total collapse of the eye pattern (no signal)**



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA



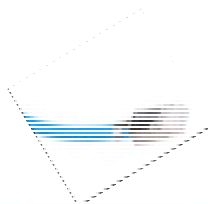
Recommendations for HDBaseT – 1080p



- Based on the results of our multi-disturber HDBaseT system testing, we recommend using a Category 6A UTP cabling system as the **preferred category cable** for AV networks that will use HDBaseT technology, to transmit an **HD 1080p signal**, immediately or in the future.
 - *Belden IBDN 10GX and 10GXS Field-Terminated and Pre-Terminated Cabling Systems*



- A Category 6/6A F/UTP shielded system can be considered as an **alternate** choice to transmit an **HD 1080p signal**. We favor shielded Category 6/6A cabling over shielded Category 5e because of lower attenuation (stronger signal to the receiver) and better overall transmission performance of Category 6/6A at higher frequencies.
 - *Belden IBDN 2400 Field-Terminated Shielded Cabling System*



- When installing a shielded cabling system, it is **critical** to maintain shield integrity at **all** connection points and to provide a uniform, low resistance path to ground for all network equipment and cabling within the premises.
 - As specified in ANSI/TIA-607-B-2011
"Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises"

HDBaseT – Cabling 4K/UHD systems

- Can we do better than a category cable?

HDMI Testing Standard

- HDMI – Set standard for commercial video quality
 - Uncompressed
 - Used as video transport for HDBaseT
 - Gold standard for testing criteria (Less than 1 in Billion)

Pass/Fail Standard: Transfer quality 1
 10^{-9} = 1 error per 1 billion pixels

Note – a 4K/UHD signal at 30 fps transmits 1 billion in 4 seconds



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

HDBaseT – Cabling 4K/UHD systems

- What did Belden do to find out?

Belden Testing

- Over 30 different types type of cables from Belden and other manufacturers
- 100 meter direct connect links using a Cat 6A field plug
- Sent 4K signal from Quantum Data analyzer and measured return signal on it
- If able to transmit signal, number of errors per 1000 frames recorded
- Repeated signal transmission 5 times
- Trim cable 10 meters, re-connectorized and repeated steps above



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

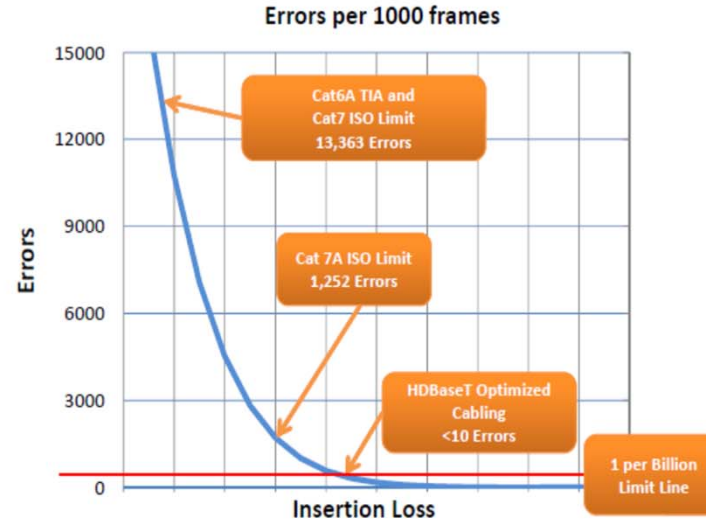


HDBaseT – Cabling 4K/UHD systems

- What we found...

Minimizing Pixel Errors

- Insertion loss of cabling designed for HDBaseT 4K UHD is better than category cabling
- 10 errors per 1000 frames is same as 1 per billion



Blue line shows the TIA standard values for each category



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA



Recommendations for HDBaseT – 4K

- F/UTP cable designed for HDBaseT - 2183
 - Not a category cable, after all it is not for Ethernet!
 - Available in riser(FT4) or plenum(FT6)
 - More flexible jacket with tight bend radius of 4x vs 6x for other cables
 - 25% thinner
 - 45 pounds of pulling tension
 - Works with REVConnect
 - UL – LP rated at 0.6 amp per conductor, more than 1 amp per pair
 - HDBaseT recommended cable
 - UL4299 PoH certified
 - Passes target of less than 1 pixel error per billion at 100 mts
 - Handles 4K



NEW! Power
over HDBaseT
(PoH)
Certified
UL4299



**Limited
Power (LP)
Certified
0.6A**



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

So how can I deliver these 4K signals?

All of these solutions work, so the key is what is best for your client?

- Coax – 4K UHD Coax delivers 12G SDI.
- HDMI 2.0 – up to 18Gbps for short distances.
- AOCs extend the HDMI distances and simplifies the installation.
- SDVoE – transmits 1080P/4K using 10Gbps networks.
- HDBaseT - transmits 5Play for a complete system including power.



2019 BICSI Winter Conference & Exhibition

January 20-24 • Orlando, FL, USA

BICSI

Thank you for your time today!

- Please stop by our Belden booth, #1007 if you would like to discuss anything further or would like to see any of these solutions.