Video Over Fiber:

Solutions for 4K, 8K and Beyond

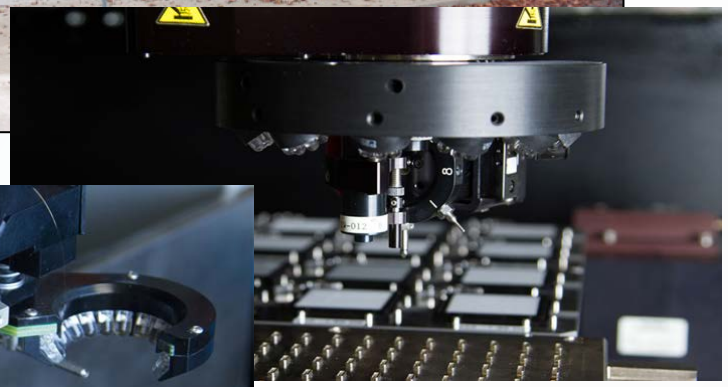
Agenda

- Emergence of Fiber in Your Industry
- Types of Optical Solutions
- Using Fiber to Improve Profits
- Getting Started with Fiber
- Summary and Q&A

Who is Inneos?

- Founded 1998
  - > Started with Medical, Comm-Sat/Aerospace focus
  - > AV over fiber since 2003
- Pioneer of single-fiber AV technology
  - > Market leader in Medical AV
  - > Primarily optical subsystem supplier for OEMs
  - > Entered ProAV market in 2017
    - 9 AV industry awards
- Vertically integrated
  - > Patented CWDM optics (technology originator)
  - > VCSELs designed and manufactured in house
  - > Highly automated, proprietary manufacturing
  - > Facilities in California and Nevada
  - > **Designed and Manufactured in good ol' California**

1998



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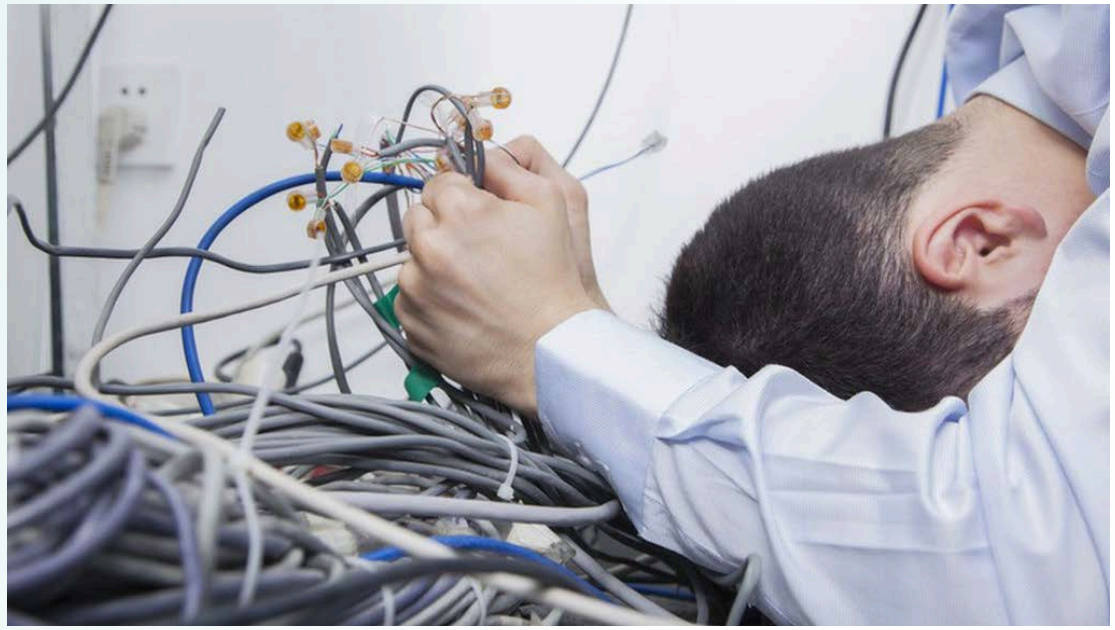
Emergence of Fiber in Your Industry

Trends In Your Industry

- Wellness
- IoT
- Lighting
- 5G
- Cable Quality/Capability Becoming a Factor

Importance of Cabling

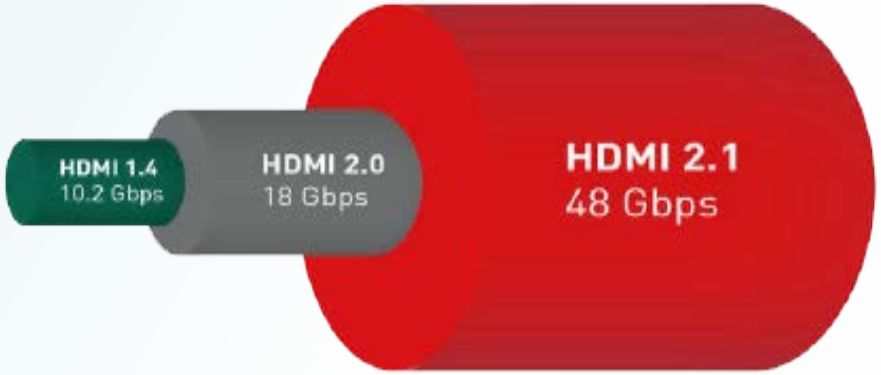
- One bad cable will turn your great system into a bad system
- A bad cable is:
  - > Broken
  - > Poorly built
  - > Poorly designed
  - > Bandwidth limited



Data Rate

Higher resolutions and HDR require more data

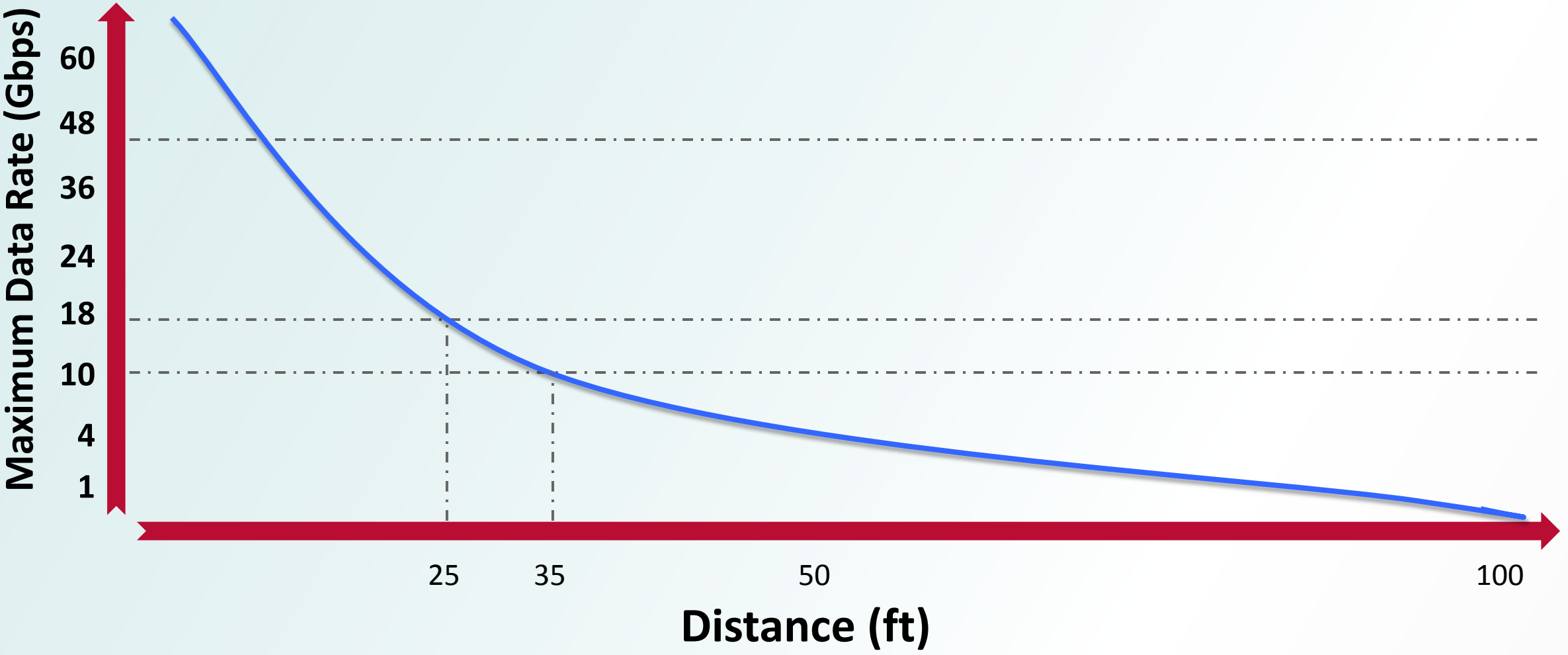
- Video data rate is 300% higher today than it was 5 years ago
  - > 1080p60 – 5G
  - > 4K60 4:2:0 SDR – 9G
  - > 4K60 4:2:0 HDR10 – 11G
  - > 4K60 Dolby Vision, or 4K60 4:4:4 – 18G
- Will more than double within next 5 years
  - > 4K120 4:4:4 HDR12 or 8K60 HDR12 – 48G



What happens when customers find out they are getting Faux-K?

The Video Interconnect Problem

Copper has insufficient bandwidth for Higher resolutions and HDR



Options To Address Data Rate Problem

- See 4K how it was meant to be seen
  - > Shorten cable run
    - Player/box behind every display
    - Install rack close to display
  - > Change to fiber
- Reduce data rate
  - > Tone down the system
    - Reduce color
    - Reduce frame rate
    - Reduce to SDR instead of HDR
  - > Compress image

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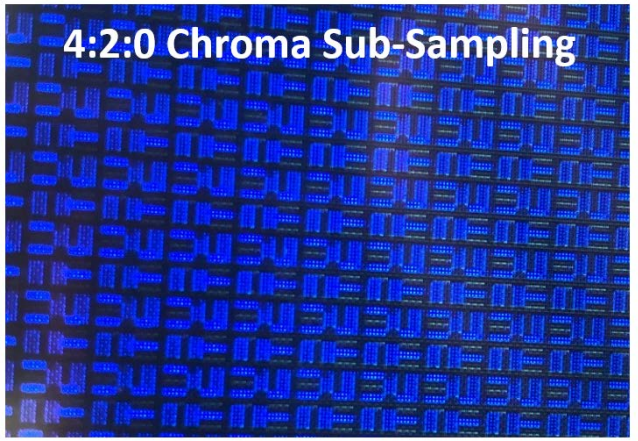
Compression – in Technical Terms

- Types of Compression
  - > Entropy coding
    - ***Lossless*** compression using patterns to reduce data rate
  - > Temporal, or inter-frame, encoding
    - ***Lossy*** or ***lossless*** that analyzes changes between frames
  - > Spatial, or intra-frame, encoding
    - ***Lossy*** compression estimates changes within a frame image
  - > Quantization encoding
    - ***Lossy*** compression compares neighboring pixels within a frame
- Can't use lossless for "final meter"
  - > Processing resources and latency are too high
- "Visually Lossless" is not Visually Lossless

18 Gbps Test Pattern Signal

Uncompressed Output



Compressed Output

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The Compression Compromise

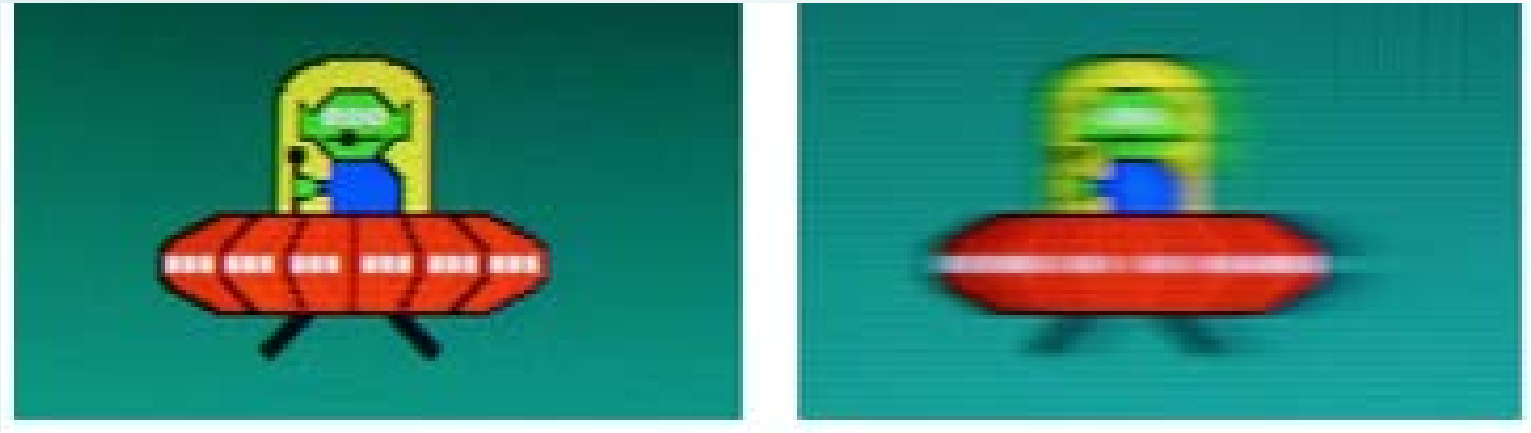
Data rate constraints can decrease the number of available colors to choose from

Banding Artifacts

No substitute for seeing a side-by-side comparison

The Compression Compromise

Variable Frame Rate drops frames, then injects estimated frames



Blurring/Aliasing Or Choppy Motion

No substitute for seeing a side-by-side comparison

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The Compression Compromise

Color Space Conversion and Chroma Subsampling throw away 75% of the color data

Blocking/Fuzzy Edges

No substitute for seeing a side-by-side comparison

The Compression Compromise

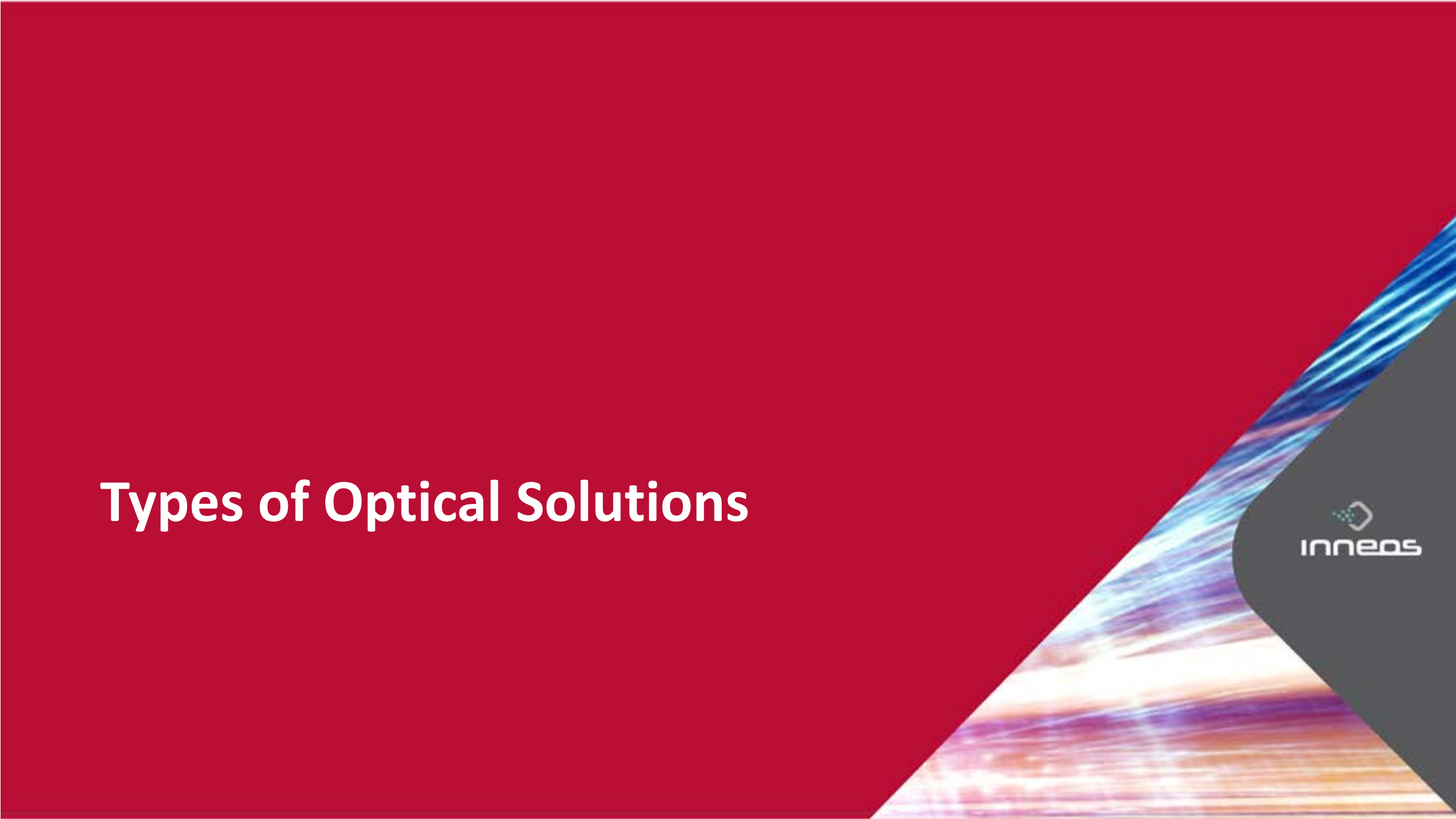
You can’t successfully compress Dolby Vision with real time algorithms

- Compression corrupts embedded metadata

Total Cost of Implementation

			9G	11G	18G	40G	48G
AV over IP/SDVoE	En/decoder $/pair		$ 3,200	$ 3,200	$ 3,200	$ 4,400	$ 4,400
	16 port switch		$ 350	$ 350	$ 350	$ 4,000	$ 8,000
	Cat Cable/run		$ 30	$ 30	$ 30	$ 30	$ 30
		1	$ 3,610	$ 3,610	$ 3,610	$ 8,460	$ 12,460
		4	$ 13,390	$ 13,390	$ 13,390	$ 21,840	$ 25,840
HDbT	En/decoder $/pair		450	450	800	1600	1600
	4x4 matrix sw		$ 2,000	$ 2,000	$ 3,000	$ 5,000	$ 6,000
	Fiber		$ 30	$ 30	$ 30	$ 30	$ 30
		1	$ 510	$ 510	$ 860	$ 1,660	$ 1,660
		4	$ 3,140	$ 3,140	$ 4,840	$ 8,440	$ 9,440
Fiber	En/decoder $/pair		700	700	700	900	900
	4x4 matrix sw		$ 2,000	$ 2,000	$ 2,000	$ 4,000	$ 4,000
	Fiber		$ 45	$ 45	$ 45	$ 45	$ 45
		1	$ 790	$ 790	$ 790	$ 990	$ 990
		4	$ 5,160	$ 5,160	$ 5,160	$ 7,960	$ 7,960

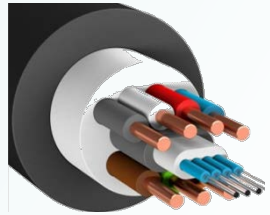
Types of Optical Solutions

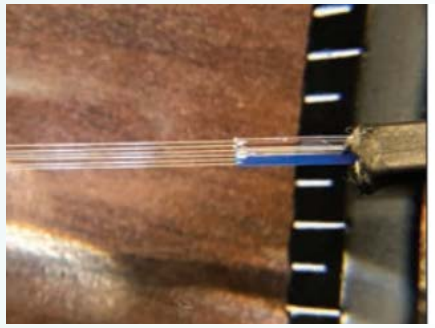


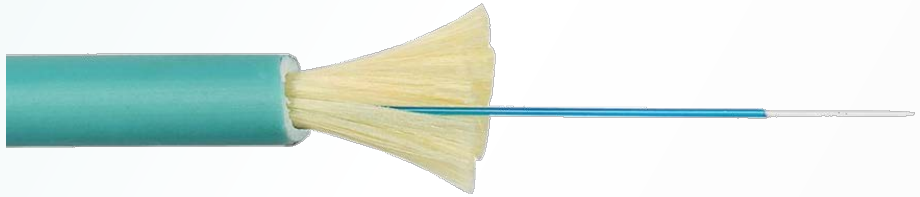
Ways to Transmit Optical Video Signals

Fiber solutions use a variety of configurations

- Parallel Hybrid Cables
  - > Parallel hybrid cable: 4 fibers + 6-8 copper wires
- Parallel Fiber Cables
  - > Parallel cable: 6-12 fibers – 1 fiber required for each laser
- Single Fiber using WDM
  - > One fiber cable with 6λ channels
  - > Fiber can easily be pulled, cut & field terminated







3 Endpoint Solutions

AV market is just becoming familiar with fiber installation

Active Optical Cables

- Typically hybrid
- Least expensive solution today
- Entire length must be pulled to upgrade or repair
- Fixed length, can't be cut

Optical Adapters

- Uses bulk fiber
- Can have control
- Modular
- Upgrade just means swapping ends

Converter Boxes

- Uses bulk fiber
- Usually has control
- Often uses 10G SFPs, which are bandwidth limited
- Typically lots of ports that go unused

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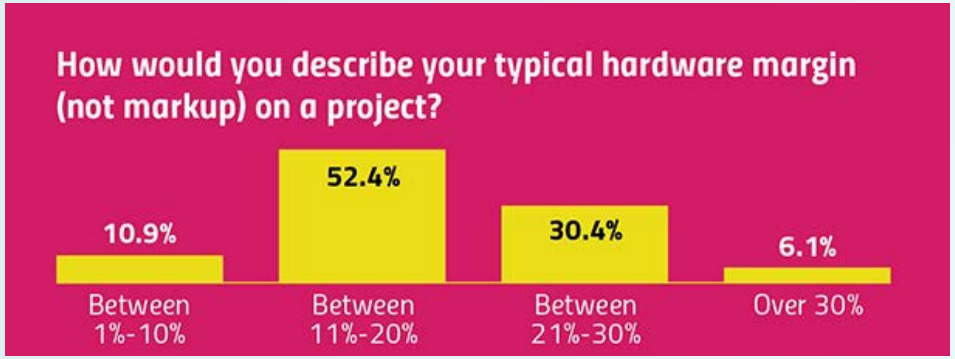
Pros and Cons of Wired Transmission Media

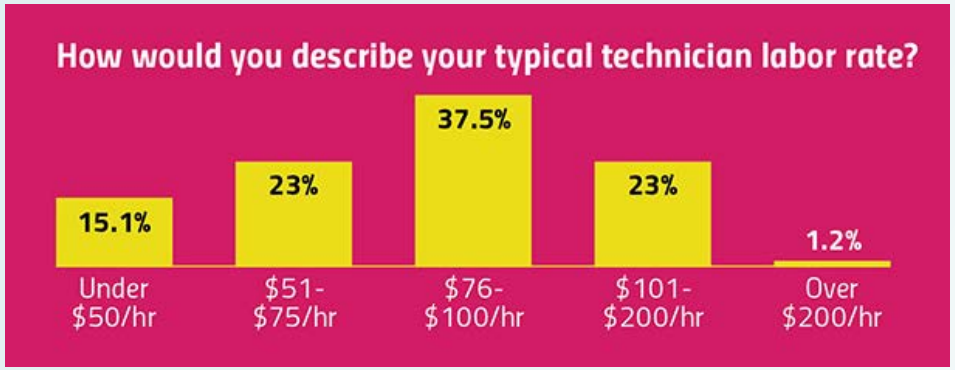
	Hybrid Fiber	Parallel Fiber	Single Fiber	HDMI Cu	DP Cu	Cat-7 Cu
Available Pre-terminated	Yes	Yes	Yes	Yes	Yes	Yes
Run Support (avg) • 18G • 48G • 96G	 Yes Yes Yes	 1000ft 800ft 100ft	 3300ft 1300ft 300ft	 30ft 15ft 5ft	 30ft 15ft 5ft	 “230ft” “130ft” 30ft
Field terminate	No	Hard	Easy	No	No	Easy
Cost to terminate	NA	$3600/kit $200/run	$400/kit $20/run	NA	NA	$200/kit $30/run
Cost in bulk (per m)	NA	$1.00	$0.35	NA	NA	$0.25
Building Code Compliance	Low Voltage	Passive	Passive	LV	LV	LV
To hide	In-wall	In-wall	In-wall or on-wall (transparent)	In-wall	In-wall	In-wall
Pull Strength	Medium	High	High	Medium	Medium	Medium
Thickness	Medium	Low	Low	Large	Large	Large
Crosstalk Susceptibility	Medium	Extremely Low	Extremely Low	Medium	Medium	High

Using Fiber to Improve Profit

Profit Margins

What drives profit?





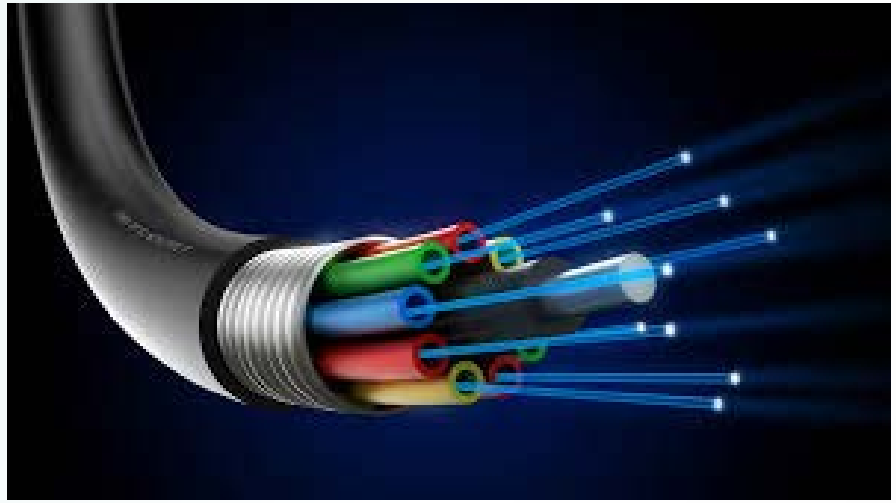
- Hardware margins only account for a portion of profit
- Lower labor costs improve the profit margin of a project
  - > Reduce installation time
  - > Fast upgrades
- Lower customer acquisition cost from repeat business

- Commercial Integrator, Jan 2018

Using Fiber Solutions to Increase Profit Margins

Why bring fiber solutions into your projects?

- Fiber is faster to pull and terminate than copper
  - > Reduces labor costs by up to 50%
- Upgrade by simply swapping endpoints
  - > Customer gets large upgrade with minimal costs
- Attain “go-to” status from you forward-thinking recommendations
  - > Customer more likely to upgrade when they realize it’s fast and painless with fiber
- Fiber is a premium technology
  - > Higher markups mean larger profits

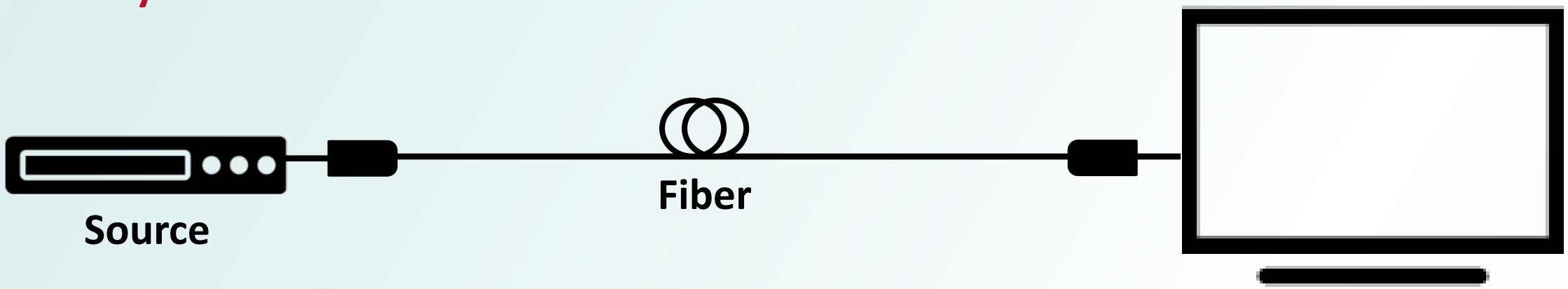


Getting Started With Fiber

Ready to get started?

Installation is simple

1. **Pick a fiber cable**
2. **Pick your extender**



Real4K Adapters

Real4K Extenders

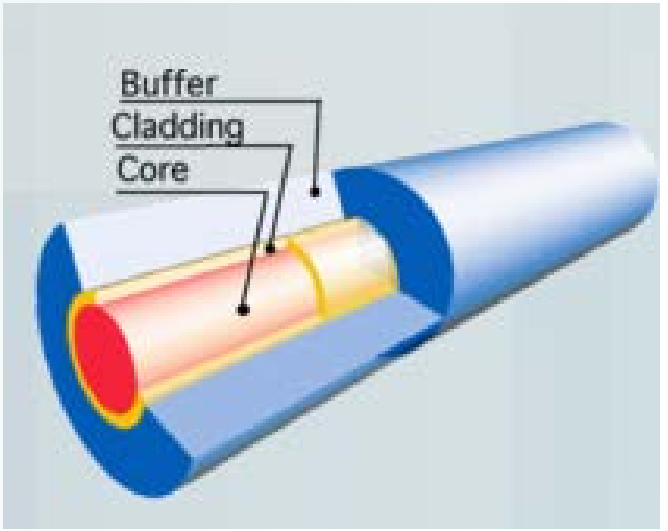
Types of Fiber Cable:

Riser
Plenum
Armored
InvisiCable

Basics of Fiber

Fiber construction

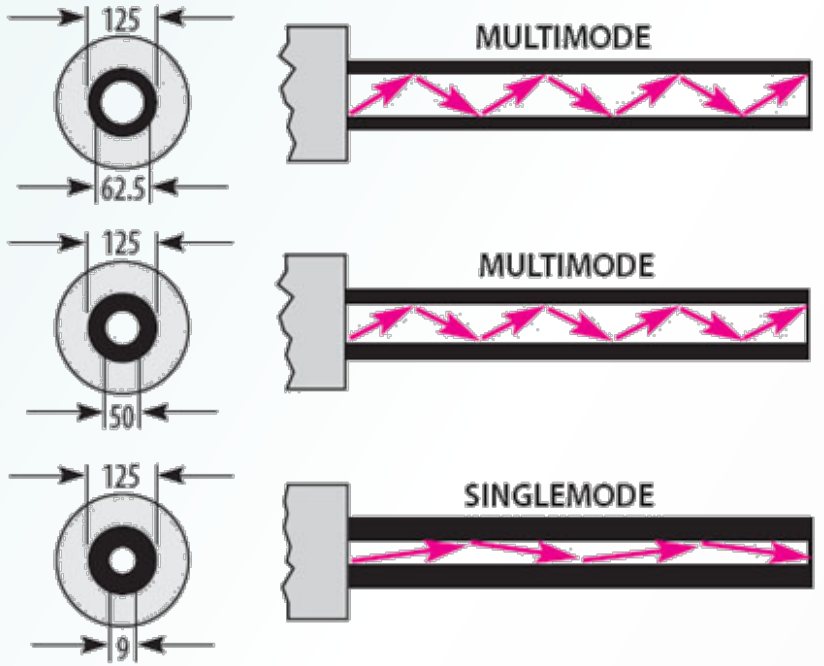
- General fiber construction
  - > Core – Primary light-guiding medium
  - > Cladding – Creates the total internal reflection allowing the light to stay in the core
  - > Buffer – Protective material around the core/cladding



Basics of Fiber

Single-mode or Multi-mode?

- Single-mode (SM) or Multi-mode (MM)?
  - > Single-mode used for Long-haul networks > 1km
  - > Multi-mode used for links up to ~2000m at 4K speeds
    - OM1 – 62.5µm core
    - OM2 – 50µm core
    - OM3 – 50µm core
    - OM4 – 50µm core

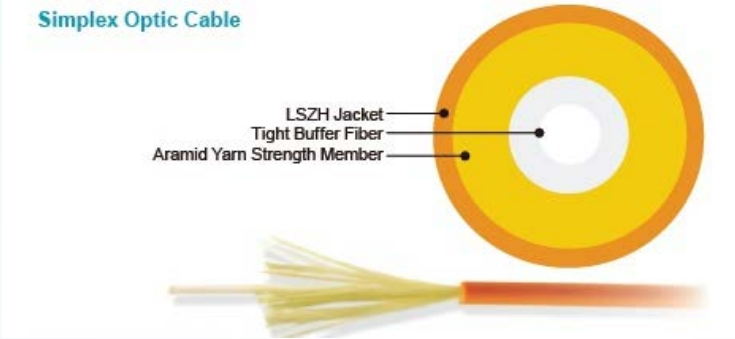


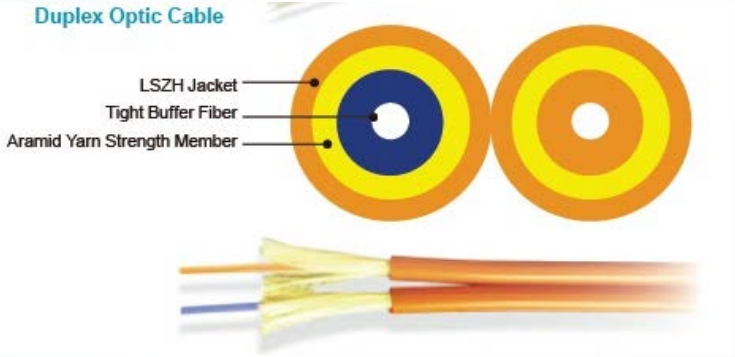
Tip: Be sure to check the equipment... single mode and multimode are NOT interchangeable!

Basics of Fiber

Fiber Cable Types

- Simplex – single run of jacketed optical fiber
  - > Very low cost, lightweight, rugged, flexible
  - > Easy to terminate in the field – only a single fiber on each end
- Duplex – run of two jacketed optical fibers side-by-side
  - > Cost about 2x simplex
  - > Sometimes run with one kept dark for future use





Picking Your Fiber

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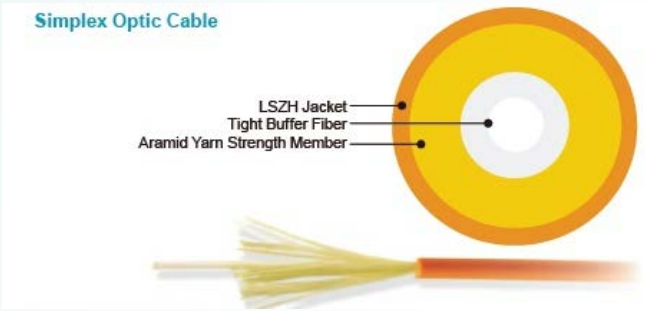
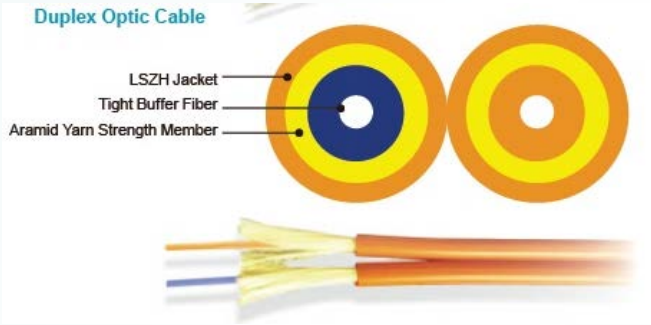
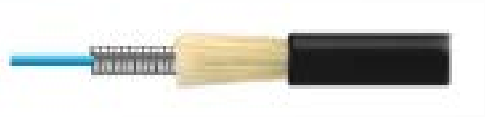




	Transparent (thin PVC Jacket)	Plenum	Armored
Thickness	.9mm/.3in	3mm/.1in	9mm/.3in
Pull Strength		115lb	200lb
Weight (300m/1000ft)	1lb	6lb	
Termination Time	<40s		
Bend Radius	3mm/.1in	3mm/.1in	



Not ready to terminate fiber?

Just use pre-terminated fiber cables

- Plenum-rated black fiber cable
  - > Bend radius of only 7.5mm
- Armored black fiber cable
  - > Crush resistance > 3000 N/100mm
- InvisiCable Fiber
  - > Clear, 0.9 mm cable hides in plain sight

Pre-Terminated Fiber Lengths

Plenum	Armored	InvisiCable
35 ft	40 ft	10 ft
50 ft	50 ft	25 ft
60 ft	60 ft	
80 ft	80 ft	
100 ft		

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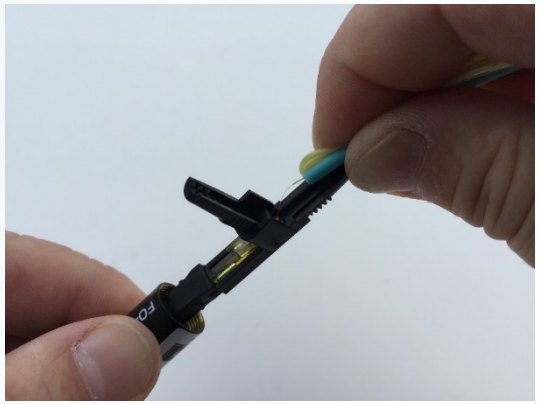
Ready to do field termination?

It’s fast and easy – even faster than Cat6a



- Process has improved
  - > Now have no-polish/no-epoxy connectors
  - > No more fusion splicing
- Kits are available from many vendors
- Just a few simple steps
  - > Prepare fiber connector and laser light indicator
  - > Strip jacketing and buffer
  - > Cleave fiber
  - > Insert fiber into connector
  - > Clamp connector and attach to fiber cable

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Picking your Extender

- HDMI 2.0b – 18 Gbps uncompressed
  - > **Supports ARC** plus, all HDCP, CEC, and EDID
  - > Supports all HDR formats, including Dolby Vision, HDR10+, HLG
- Easy Integration
- Pass-through of control signals

Hey Look, I Found One

Inneos Real4K BPK-XT

- HDMI 2.0b – 18 Gbps uncompressed
  - > **Supports ARC** plus, all HDCP, CEC, and EDID
  - > Supports all HDR formats, including Dolby Vision, HDR10+, HLG
  - > Multi-color LED for detailed link status and troubleshooting info
- Up to 3300 ft
- Easy Integration
  - > Detachable HDMI cable (up to 6 feet on either side)
- Pass-through of control signals
  - > IR pass-through with R4K-IRB cables (available today)
  - > RS232/Serial control - *coming soon*
- Product family has a path to Real8K

TNT TOP NEW TECHNOLOGY AWARDS@ISE 2019 CEPro Commercial INTEGRATOR

Residential Video Extension

TNT TOP NEW TECHNOLOGY AWARDS@ISE 2019 CEPro Commercial INTEGRATOR

Commercial Video Extension

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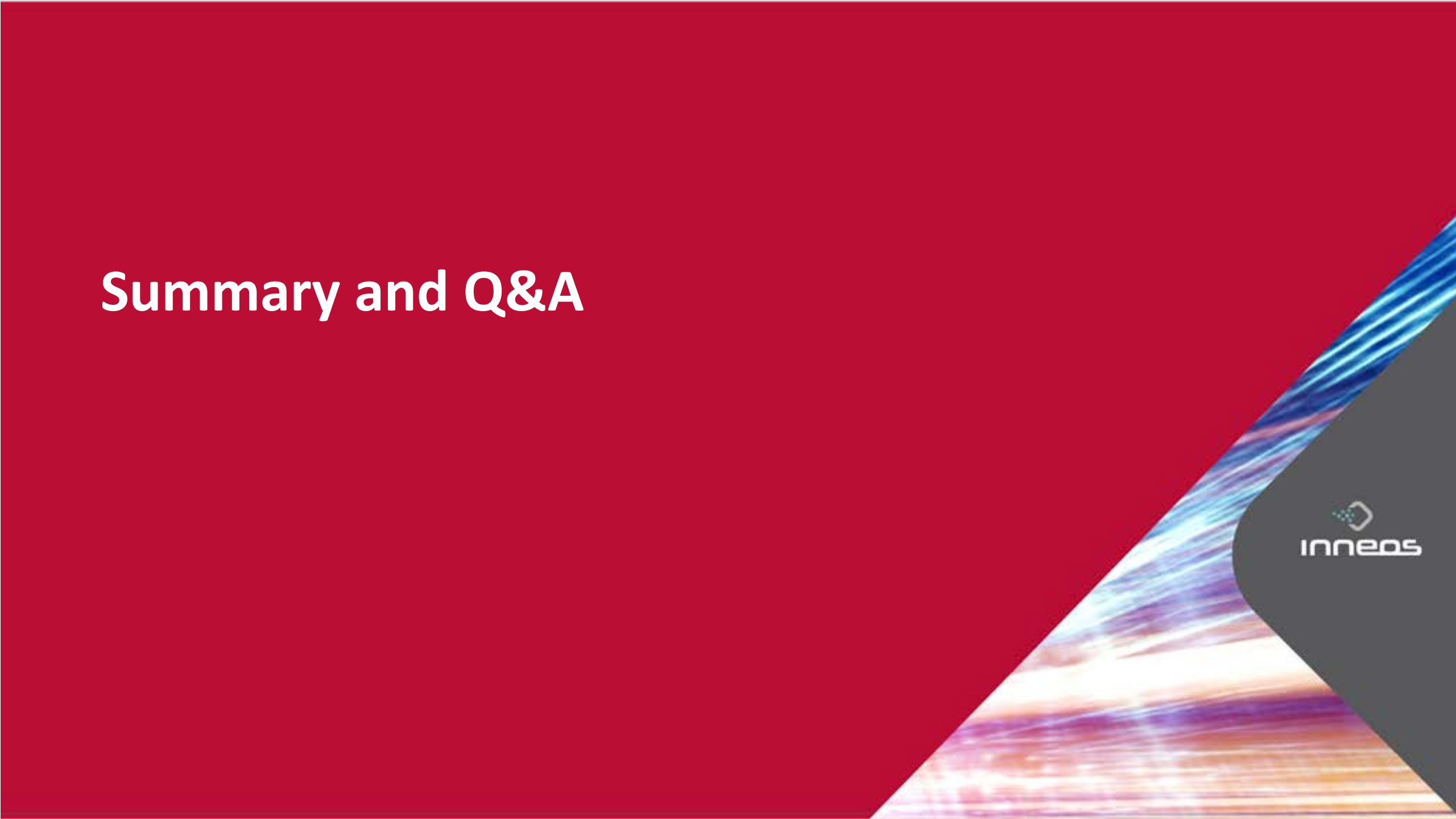
Summary and Q&A



Summary

Key Takeaways

- Data rates are driving change
  - > Moving to 48 Gbps soon… Copper has reached its limit
- Compression is evil
  - > Visually Lossless = Marketing Handwaving for Lossy Compression
- Fiber is the future
  - > Future-ready - supports **way beyond 8K**
  - > No compression needed
- Fiber increases profit
  - > Labor time is reduced
  - > No EMI, AXT
  - > Simple upgrade to 8K with Inneos extenders

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Appendix

Technical info on fiber coming up…

Real4K Extender LED Status Indicator

- Provides fast, easy trouble-shooting
  - > Not just power information, but actual link status
  - > Allows for quicker troubleshooting

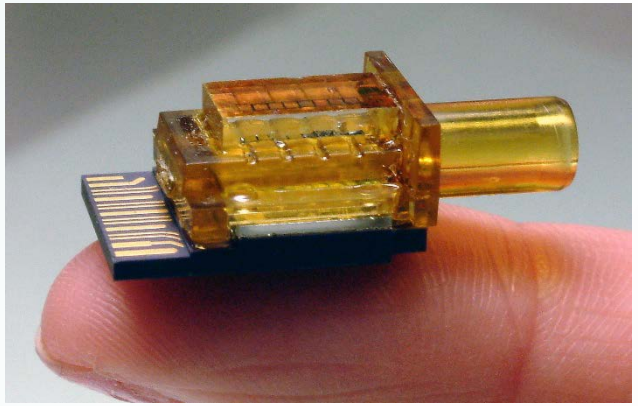
- Tips for troubleshooting:
  - > If LED is red/pink, the issue is the fiber link
  - > Check the firmware version if having HDCP issues
    - Firmware is field upgradable

COLOR	LINK STATUS
OFF	EXTENDER END HAS NO POWER
RED	EXTENDER DETECTS AN OPEN FIBER CONNECTION AND HAS DISABLED THE LASERS
YELLOW	FIBER LINK DETECTED BUT HDMI INITIALIZATION FAILED
WHITE	VIDEO ACTIVE WITHOUT HDCP ENCRYPTION
GREEN	VIDEO ACTIVE WITH HDCP 1.X ENCRYPTION
BLUE	VIDEO ACTIVE WITH HDCP 2.X ENCRYPTION

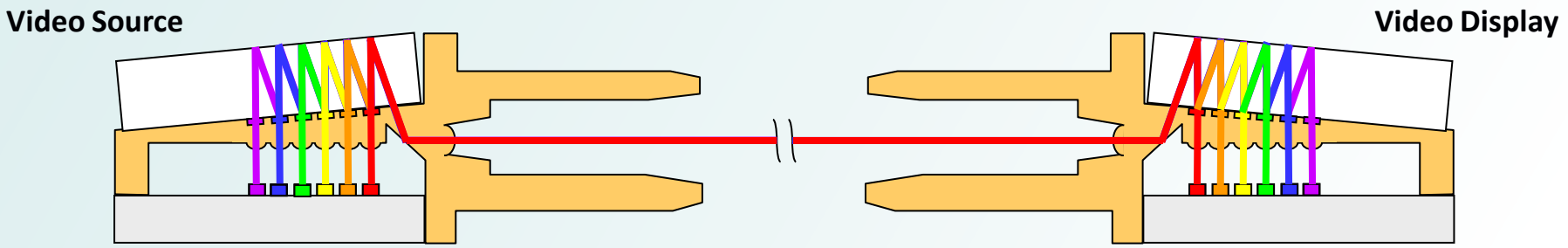
Inneos' Optic with WaveStacker Technology

ALL of the HDMI signals on a Single Industry Standard Fiber

- Technical Term: WDM – Wavelength Division Multiplexing
  - > Light can simultaneously travel both directions without interference if the wavelengths are different
- Inneos solution only needs one fiber



Inneos Optic



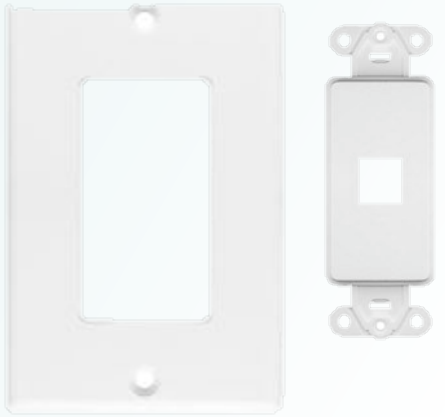
WaveStacker animation showing path of different wavelength lasers (including backchannel)

Fiber Accessories

Integration made simple

- Wall plates
  - > Use standard keystone inserts
- Optical keystone inserts
  - > SC-SC coupler
- Patchcords
  - > Short fiber connections
    - Use SC-SC, UPC, Multimode fiber
    - Some convert from LC to SC

- Where to get it?
  - > Some distributors
  - > Amazon
  - > FS.com
  - > Leviton QuickPort system



<u>Tip:</u> Fiber couplers are mechanical connectors, so the color doesn't matter, just the type (SC-SC, LC-LC)

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Industry-Standard Fiber

Spec fiber cables for the future

- Standard multimode fiber supports long distances
  - > OM4 or OM3 offer best future-proofing

Video Rate per Channel	Fiber Type:	OM2	OM3	OM4
1080p 12bit color (2.25Gbits/s)	Max. Distance (ft)	1706	6363	7970
4K 30Hz 4:4:4 (3.0Gbits/s)		1050	4034	6199
4K 60Hz 4:4:4 (5.97Gbits/s)		492	1902	3280
8K Full Rate (12.0Gbits/s)		279	656	1197

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Industry-Standard Connectors

Choose connector based on equipment

- Types of Connectors
  - > **SC – good for field termination, used with Inneos products**
  - > LC – small and compact, frequently used in ultra-dense datacenters
  - > ST – spring loaded twisting connector

SC Connector

LC Connector

ST Connector