

ICT Cabling Considerations for SMPTE 2110



March 2019
Dennis Cotter – Belden FAE West

BELDEN
SENDING ALL THE RIGHT SIGNALS



Purpose; Process; Payoff



Purpose

- To provide an overview of considerations for implementing a SMPTE 2110 cabling plant



Process

- Presentation & Discussion highlighting:
- Copper and Fiber Connectivity solutions for SMPTE 2110



Payoff

- Comfort level in ICT Cabling for Broadcast Applications



A Rich Heritage

- Founded by **Joseph Belden** in **1902** in **Chicago**
- A long **history of innovation** for communications technologies
- Early customers included **Thomas Edison**



Radio in the 1920s



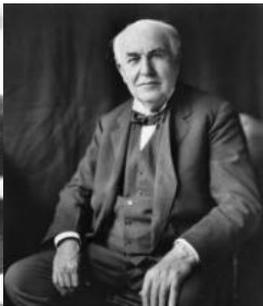
TV in the 1950s



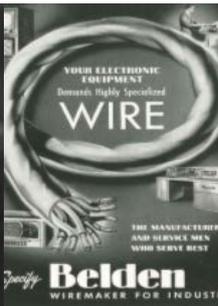
Computer Networking in the 1980s and 1990s



Joseph Belden



Thomas Edison



Belden Today

- John Stroup, CEO
- Headquartered in **St. Louis, MO**
- **10,000** employees
- NYSE: **BDC**
- Operations in **North and South America, Europe, Middle East, Africa** and **Asia Pacific**
- Revenue **\$2.39B**
- **20+** Sales Offices; **25+** Manufacturing Facilities

Delivering highly engineered signal transmission solutions for mission-critical applications in a diverse set of global markets

Key Markets	Applications	Solutions
Enterprise <i>Smart Buildings</i> <i>Final Mile Broadband</i> <i>Live Media Production</i>	 Video	Cable
Industrial <i>Discrete Manufacturing</i> <i>Process Facilities</i> <i>Transportation</i> <i>Energy</i>	 Audio	Connectivity
	 Data	Networking
		Software

Two Business Platforms Delivering Innovative Connectivity Solutions



Broadcast Solutions



- Broadcast Cameras
- Live Production Systems
- Routers and Interfaces
- Broadcast Connectors
- Broadband Connectivity
- Playout Systems

Enterprise Connectivity Solutions



- Racks and Enclosures
- Copper and Fiber Connectivity
- Ethernet, Fiber Optic and Coaxial Cabling
- Custom Infrastructure Solutions

Industrial Connectivity Solutions



- Connectors
- Industrial Cable
- Patch Cords
- Distribution Boxes
- Customized Connectivity Solutions

Industrial IT Solutions



- Ethernet Switches and Routers
- Security Devices
- Network Management Software

BELDEN



A BELDEN BRAND

BELDEN



BELDEN



SMPTE 2110 – What is it?

Standard developed to support/exploit the next generation of transport technologies designed for Ethernet, Internet Protocol (IP) and Real time protocol (RTP)

SMPTE 2110 offers all the advantages of a heavily multiplexed SDI coaxial signal transport; with all the flexibility of each media format, or essence being, independently accessible in a common physical layer and switch fabric.

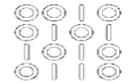
SMPTE 2110 includes reference to SMPTE 2059 -1/2 in order to provide accurate PTP timing distribution throughout the facility.

Chuck Meyer
Grass Valley

Why IP Routing?



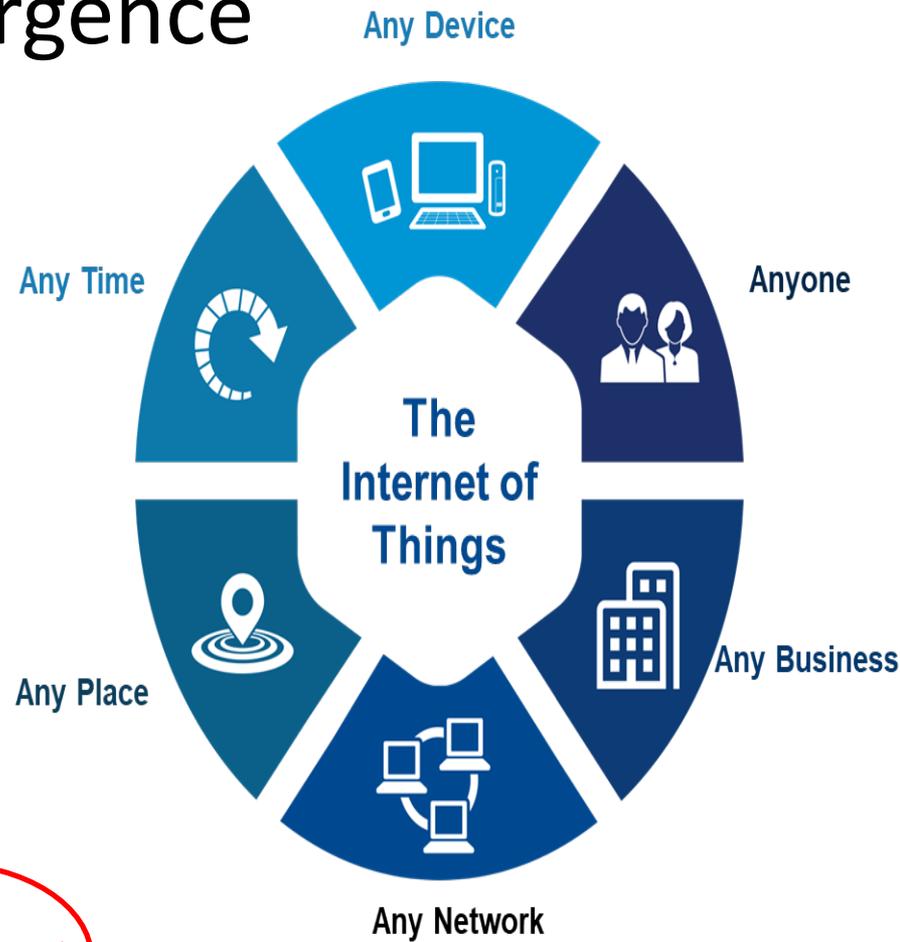
- **Cost** — The cost of high-bandwidth IP equipment and circuits has been dropping steadily for several decades
- **Ubiquity** — IP networks have been deployed everywhere that humans go today - \$10B+ invested each year compared with 10's of millions in baseband SDI
- **Common Timing** — With bidirectional links throughout an IP-based facility, broadcasters will no longer need to construct separate signal paths to distribute sync signals to devices.
- **Simplified Infrastructure – UTP / Fiber**
- **Reduced Bandwidths** - a SMPTE ST 2110-20 signal with 1080p video occupies less than 2.67 Gbps
- **Improved Versatility:** SMPTE ST 2110-23 includes a robust mechanism for defining a wide range of video formats, including multiple bit depths, multiple colorimetry schemes, any conceivable frame rate, and other associated parameters.



ICT SMART Facility



Convergence



Broadcast

Traditional Broadcast & Media routing

Connectivity

Copper



BNC

Video



HD-BNC



Audio



Multi-way 'D' type for Analog & AES Digital. BNC for MADI

Fiber (SM/MM)

SFP*



3G/HD/SD-SDI

Dual Transmitters (2x Tx)
Dual Receiver (2x Rx)
Transceiver (Tx/Rx)

AES MADI 100Mb/s (Tx/Rx)

Broadcast & Media

Video + Audio + Data

SDI Video + Embedded Audio (x16)
+ User data (270Mb/s, 1.5/3Gb/s)

Video

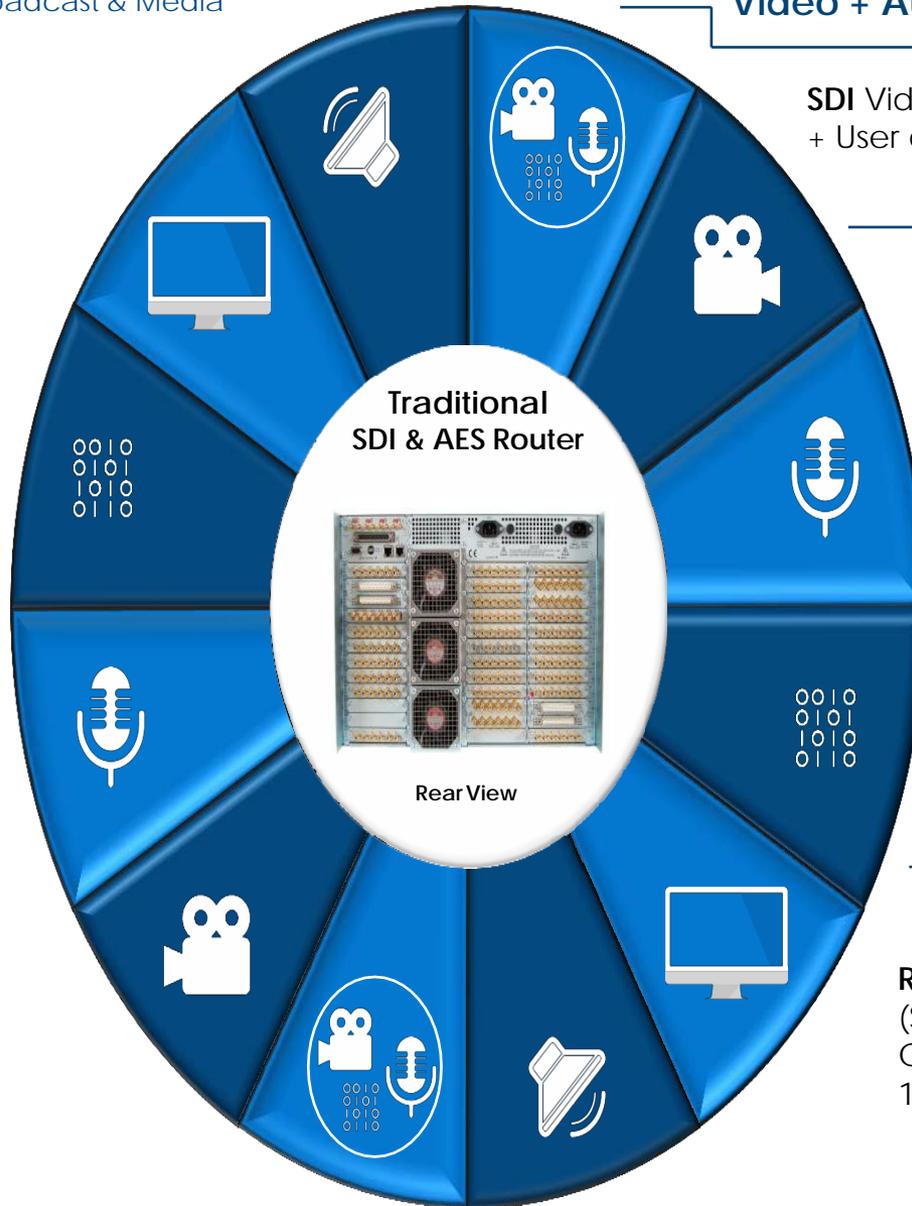
SDI Video
(270Mb/s, 1.5/3Gb/s)

Audio

AES Digital Audio
(3Mb/s – 48kHz sampling)
Balanced - Differential
Unbalanced - Single Ended

Data

RS485 Serial - Older systems!
(Separate or integrated)
Currently more likely separate
100MbE or GbE IP Switch



IP World of Broadcast & Media



Connectivity

Copper



RJ45

SFP
(Copper)

Up to 10GbE*

Fiber

SFP*



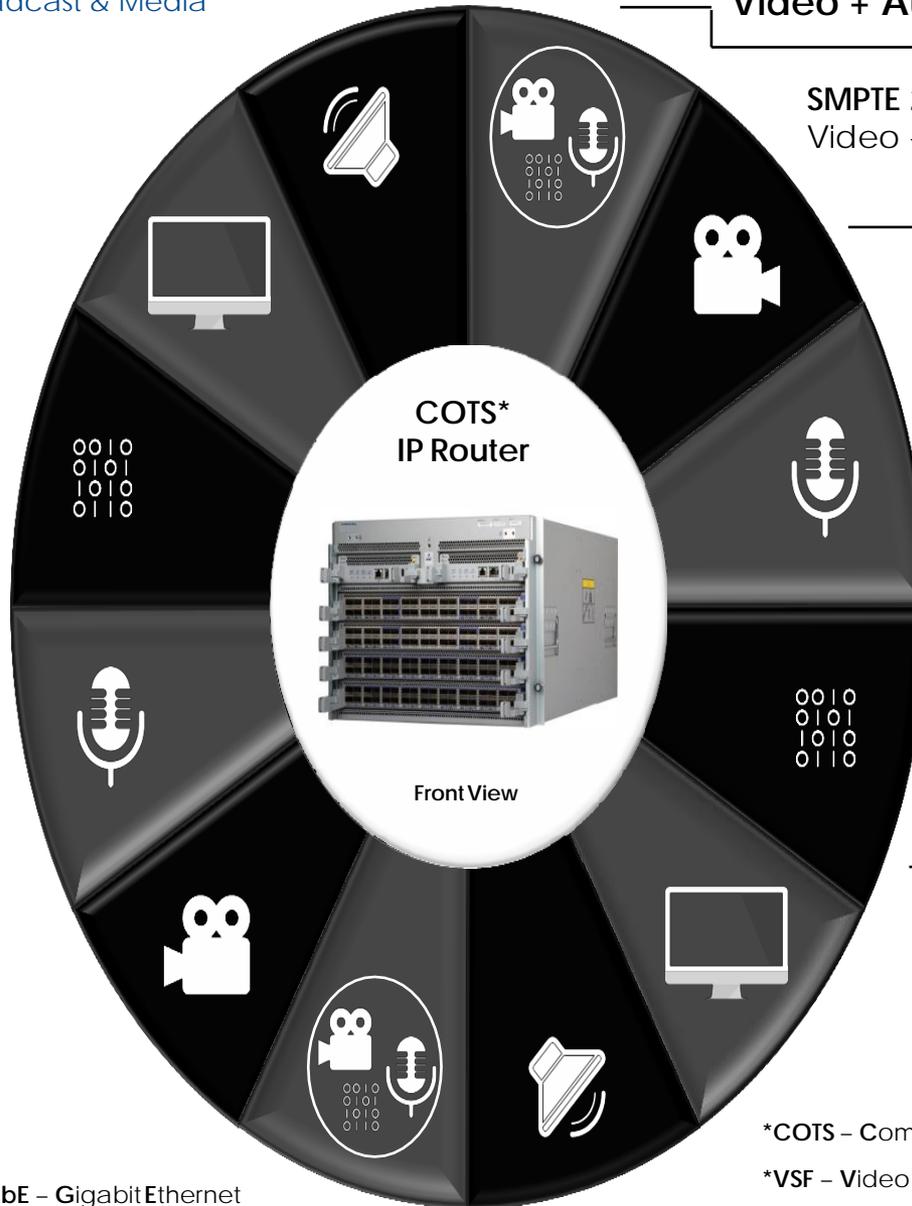
10GbE SFP+

25GbE SFP28

QSFP+ QSFP28



40/100GbE



Video + Audio + Data

SMPTe 2022-6/-7 IP wrapper for SDI
Video + Embedded Audio + Data

Video



VSE* TR-04 SDI but video only
VSE TR-03 Video to RTP
Payload format (2110-20)
Map VANC separately

Audio



AES67 Digital Audio
High-performance
IP streaming for Production
Supported in (2110-30)

Data



TCP-IP Ancillary
Data (2110-40)

COTS*
IP Router

Front View

*COTS – Commercial Off The Shelf

*VSE – Video Services Forum

IETF – Internet Engineering Task Force

*GbE – Gigabit Ethernet

*SFP – Small Form-factor Pluggable

TIA Standards

Most Common Cabling Standards;
Copper & Fiber - Performance
Based





What are Standards?

Codes

Protect life limb and property, but nothing has to work.

Standards

Ensure a minimum level of performance with minimum standards with no value/cost/comparisons allowed. Typically ISO, ANSI, TIA and some BICSI documents.

Best Practices

Give recommendations based on perceived 'value' to maximize 'value'. Subjective. Typically BICSI or other association documents.

Manufacturer Guidelines

Typically a set of practices tied to a specific product line (may explain deviation from standards and/or best practices).

Marketing

A description of the vendors capabilities from a product and service standpoint ... not necessarily tied to any of the above

The Standard Committees



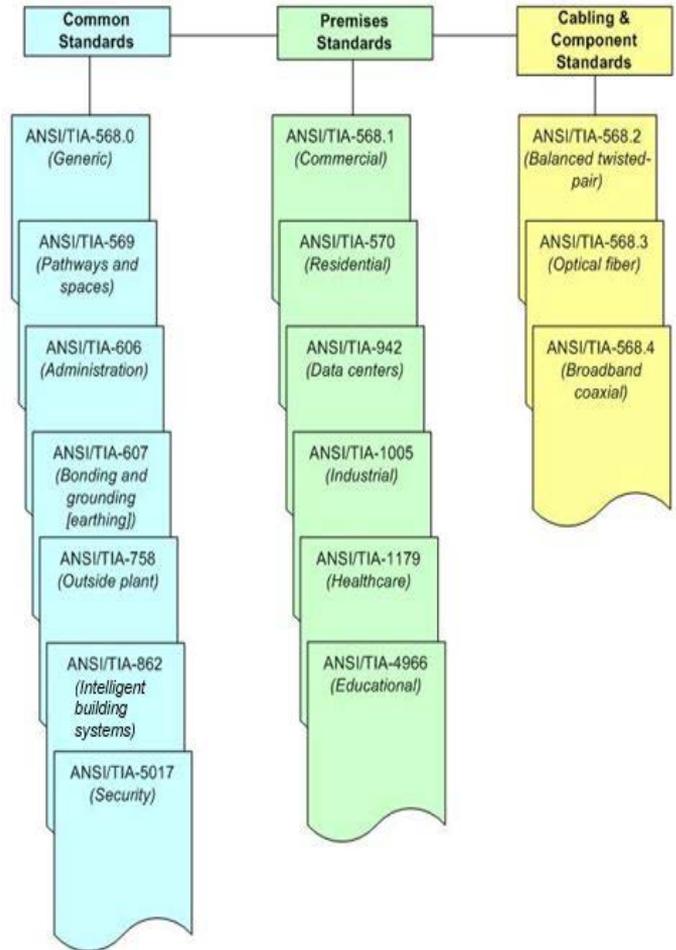
- TIA/EIA North American Standard – Cabling
- ISO/IEC International Standard – Cabling
- Cenelec European Standard – Cabling
- IEEE International Standard - Networking

Standards Evolution

	 IEEE	 TIA	AV
2015	40GBASE-T	Cat 8	
2010			AVB HDBaseT
2005	10GBASE-T	Cat 6A OM4	
2000	1000BASE-T	Cat 6	Blu-Ray HDMI
1995	100BASE-TX	Cat 5e OM2	DVD
1990	10BASE-T	Cat 5	Analog (Coax)
1985		Cat 3 OM1 Proprietary	

Revised Organization & Document Structure

- TR42 – Plenary
- TR42.1 – Premises Telecommunications Infrastructure
 - Now includes Residential, and OSP as well as Healthcare , data centers and sustainability
- TR42.3 – Telecommunications Administration, Pathways, Spaces, Bonding and Grounding
- TR42.5 Terms
- TR42.7 Copper Cabling Systems
- TR42.9 Industrial
- TR42.11 Optical Systems
- TR42.12 Optical Fibers and Cables
- TR42.13 Passive Optical Devices and Fiber Metrology



TR42.1 Commercial Building Standards (What's New)

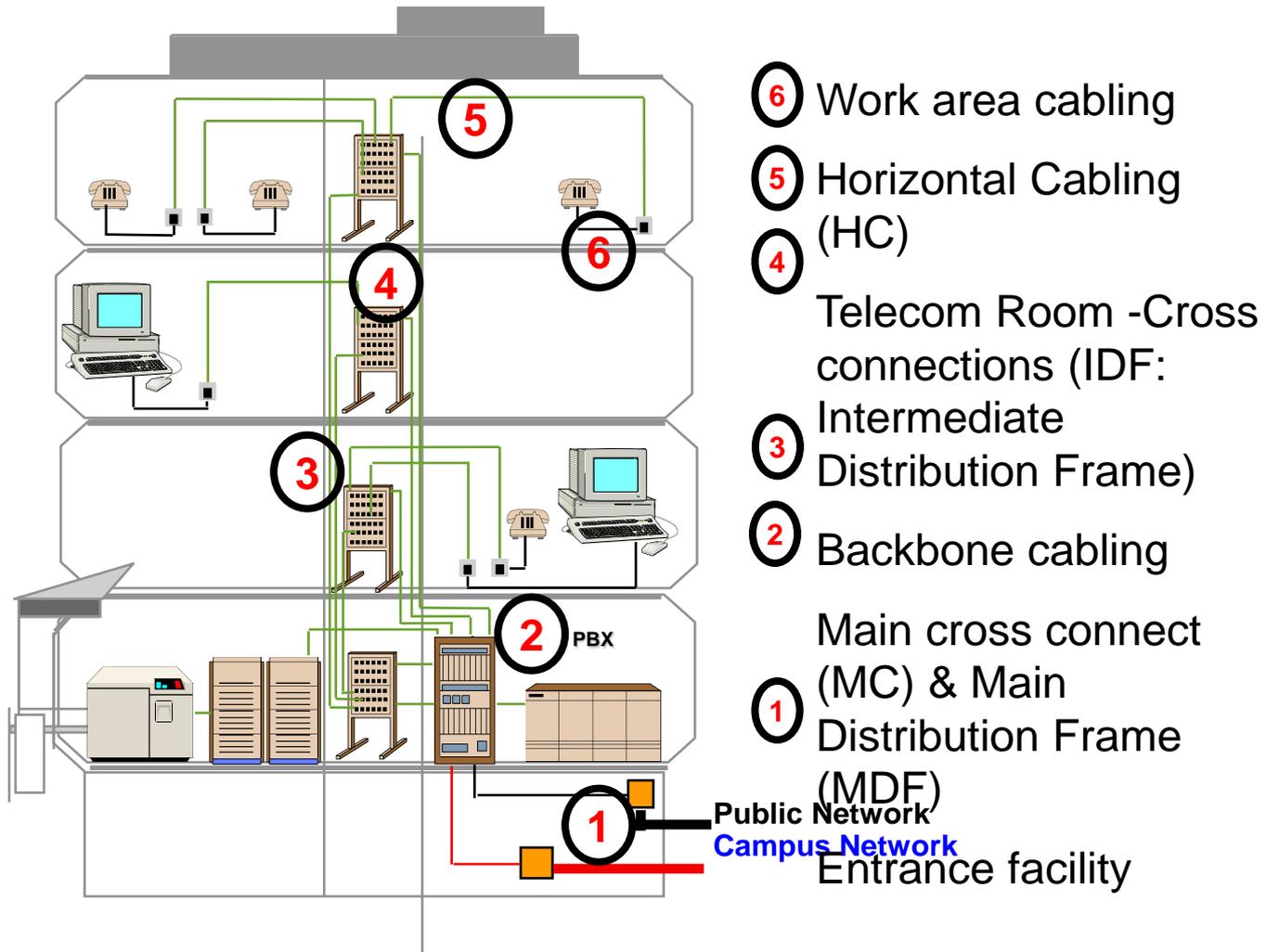
- 568.1-D.1 (Commercial) – Published
- 570-D (Residential) – Comments resolved, will go out for default ballot and conditional publication
- Updated documents for Residential* (in progress), OSP* (in progress), Intelligent Building Systems/BAS, Data Centers, Healthcare, Education and DAS (TSB)
- **Near term projects Places of Assembly**, single Pair Ethernet (addenda to 568.0 and 862)



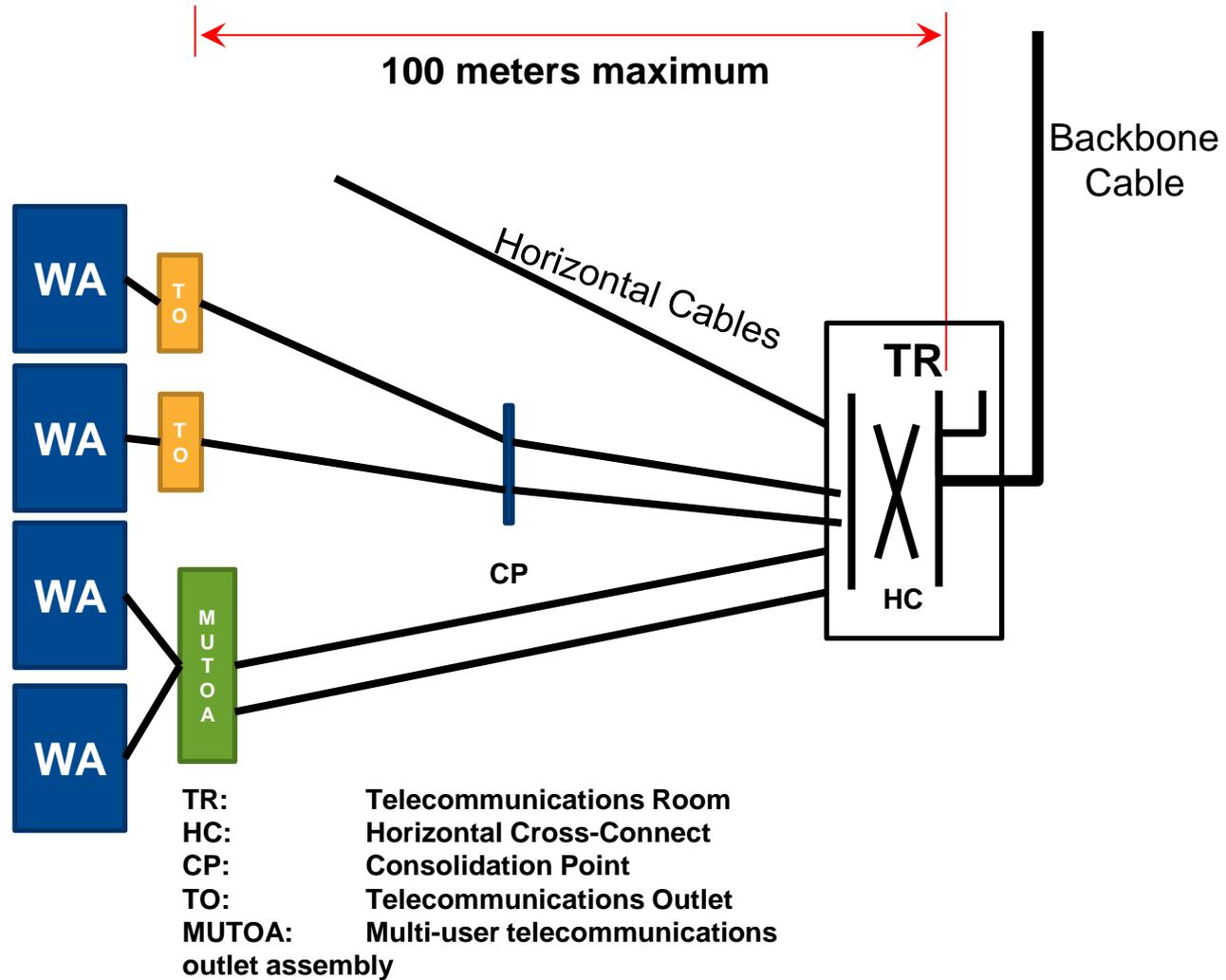
Structured Cabling – Copper or Fiber

- Standards specify:
 - Cable to be used
 - Connectors
 - Topology of the network
 - Distance
 - Number of connections allowed
 - Performance
 - Installation guidelines
 - Labelling of the system
 - Testing requirements

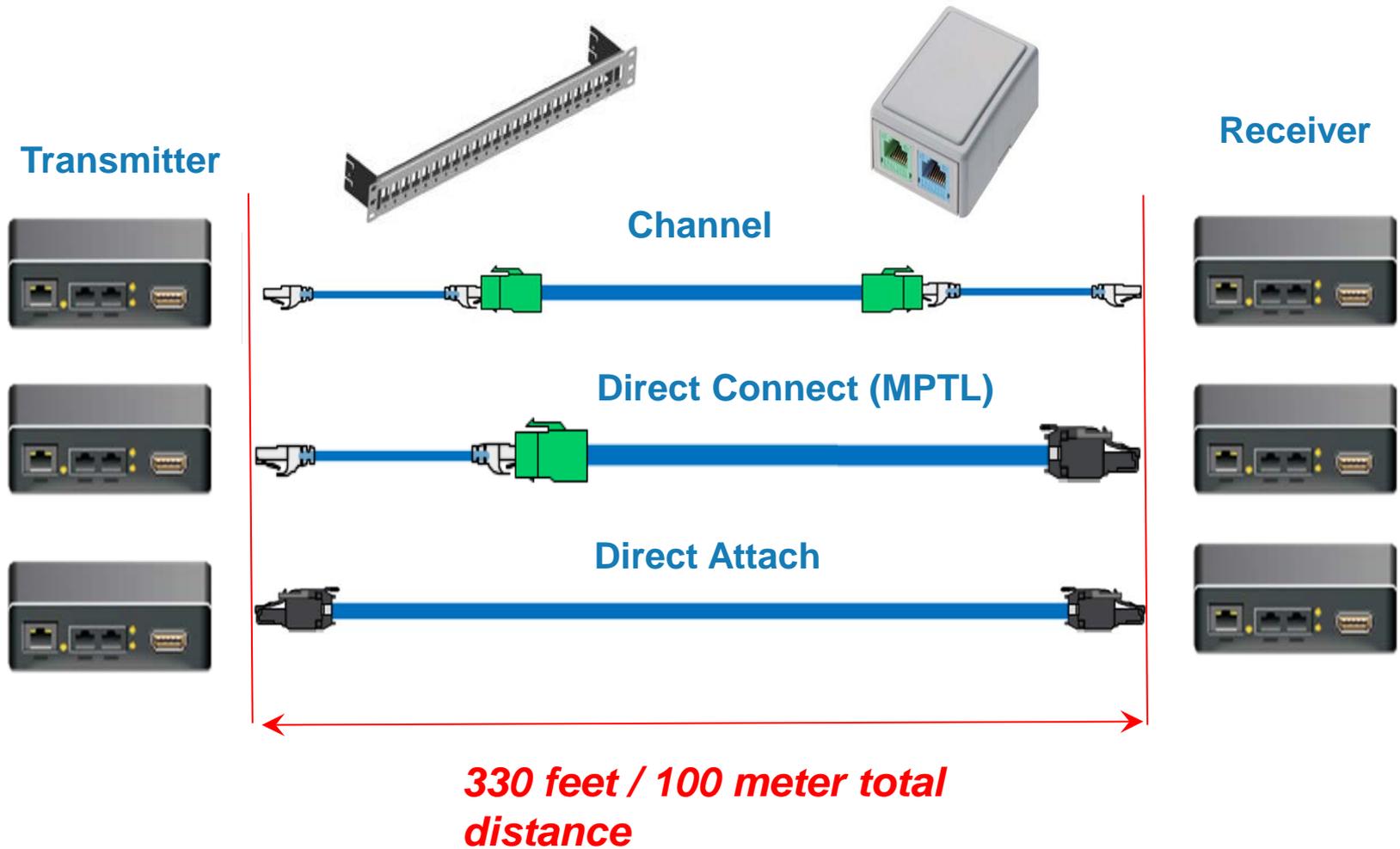
Cabling Infrastructure Areas



Horizontal Cabling - Star Topology



Direct Attach vs Channel vs Direct Connect

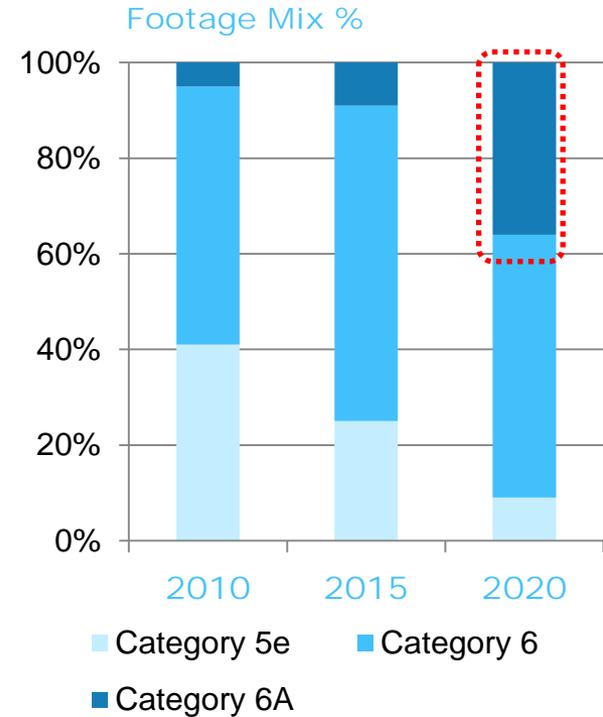


Category Cabling

U/UTP (Unshielded Twisted Pair)



Standard	Bandwidth	Max. Throughput	TIA Recommendation
Category 5e	100 MHz	1G (2.5G*)	Legacy
Category 6	250 MHz	1G (5G*)	Minimum
Category 6A	500 MHz	10G	Recommended
Category 8*	2 GHz	25/40G	Data Center Switch to Server



F/UTP (Foil, Unshielded Twisted Pair)



S/FTP (Shielded, Foiled Twisted Pair)





Copper Field-Term Systems Components

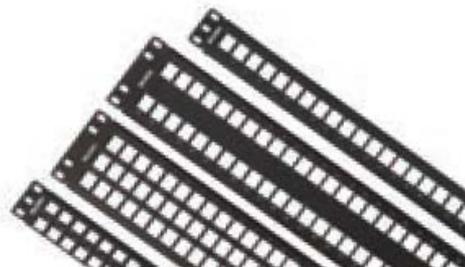
Jacks / Plugs



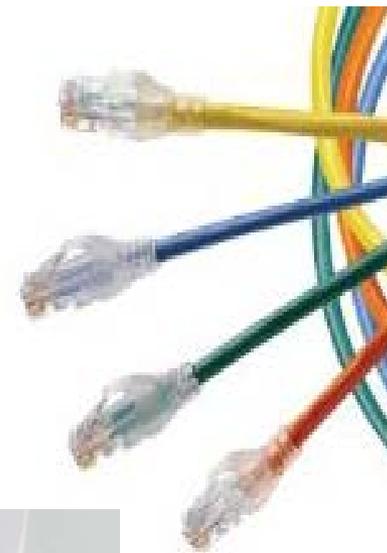
Cable



Patch Panels



Patch Cords



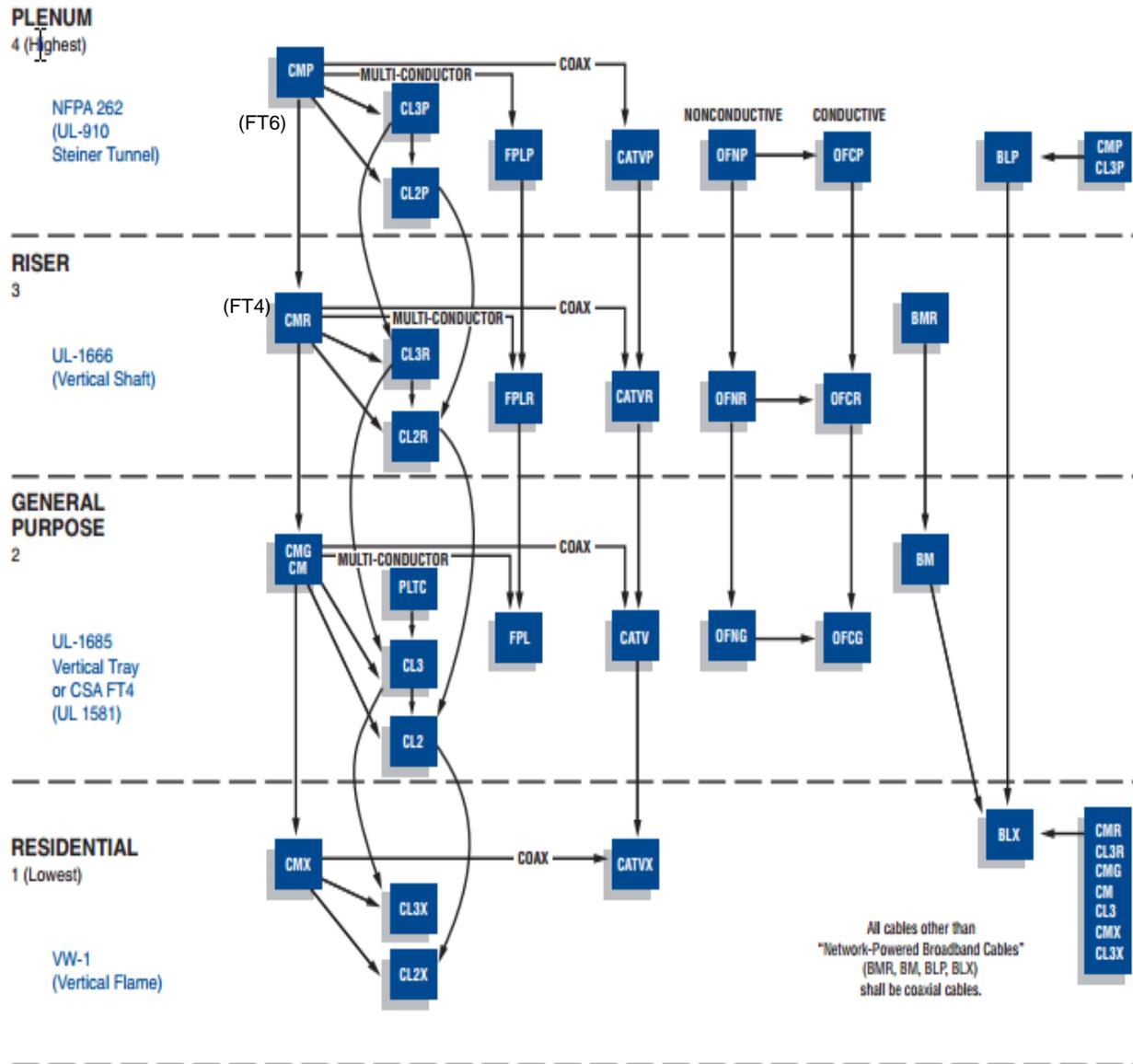
**Workstation
Outlets**



Tools



National Electric Code Rating (US)





PoE Evolution

	2003	2009	2018			
Standard	IEEE 802.3af	IEEE 802.3at	IEEE 802.3bt			
Acronym	PoE	PoE+	4pPoE			
			Type 1	Type 2	Type 3	Type 4
			2 pairs	4 pairs	4 pairs	4 pairs
Source Current (max. per pair set)	350 mA	600 mA	350 mA	300 mA	600 mA	960 mA
Source Voltage (min.)	44 V	50 V	44 V	50 V	50 V	52 V
Source Power (max.)	15.4 W	30 W	15.4 W	30 W	60 W	100 W

Bundling restrictions and an LP (Limited Power) rating has been added to the NFPA70 2017

The addition of an ampacity vs bundle size table and the LP rating is the NFPA's answer to cable bundles heating-up due to PoE

The intent is to regulate the PoE amperage/wattage while considering the cable's:

- AWG size

- Temperature rating

- Number of cables installed together or bundled.

LP ratings represent the maximum current per conductor.

Valid ratings include: 0.5A, 0.6A, 0.7A, 0.8A, 0.9A or 1.0A

Example Surface Marking:

“MFG Part Number CMP-LP (0.6A) (UL) 23 AWG 90C”

LP Ratings are required for:

Power sources delivering > 60W

Power Delivery Distance Comparison

Constant Voltage DC Power Source

Single Pair Analysis		Max Reach (meters)		
		14A WG	18AWG	20AWG
Power (Watts)	50	310	122	77
	100	155	61	n/a
	1000	n/a	n/a	n/a

Digital Electricity Power Source

Single Pair Analysis		Max Reach (meters)		
		14AWG	18AWG	20AWG
Power (watts)	50	2000	2000	1382
	100	2000	1095	689
	1000	259	103	65

Extended Reach possible with mutual capacitance that is both **uniform** and **<50pF/ft**



Installation Considerations

- When installing horizontal cabling these key points need to be addressed:
 - Pathways (40% initial fill rate)
 - Pulling Tensions
 - EMI Sources
 - Bend Radius
 - Unjacketing and Untwisting of Pairs
 - 568A and 568B pinouts

Horizontal Pathways



- Cable/Basket Tray

- Conduits

- Ceiling

- J-Hook (every 4-5 ft.)

- Arlington Strap

Horizontal Pathways



- Raised access floor
- Surface mounted raceway
- Power pole

Fiber Raceways



✓ Fiber Ducts = LZSH

- 2x2
- 4x4
- 4x8
- 4x12

✓ Cable Routing

- Elbows, Trumpets, Downspouts, etc.

✓ Cable Routing

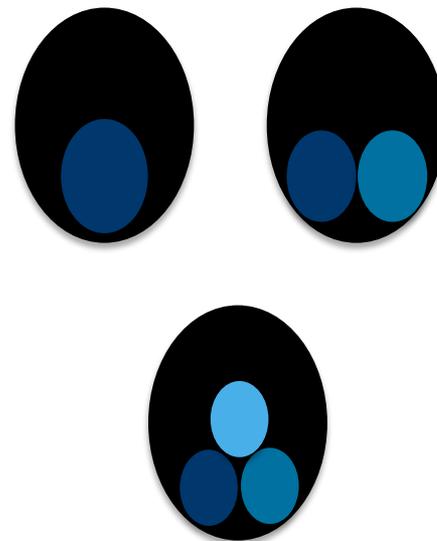
- Lids, Tool-less & Mechanical joiners

✓ Mounting Kits



Cable Calculations For Tray or Conduit Fill

- The area occupied by the cable vs. the total area inside
- Per the Standard (not code), remember these are NEC Chapter 8 products
- No more than 25% fill initially
 - 1 cable 52% fill
 - 2 cables 31% fill
 - 3 or more 40% fill



Product	Conduit				Basket Tray	Vert/Horiz Manager		J-Hook	Bundle
	¾"	1"	2"	4"	4"Dx12"W	3"x1"	3"x3"	2"	OD (48)
10GXS CMP	4	6	24	107	431	27	82	46	2.16"
10GXS CMR	3	6	23	101	406	26	77	44	2.22"
10GX	3	5	19	86	347	22	66	37	2.40"
Competitor Average	3	4	18	82	329	21	62	35	2.47"

Pathway fill used: Conduit 40%, Basket Tray and Vert/Horiz Manager 50%, J-Hook 70%



Bend Radius - Conduits

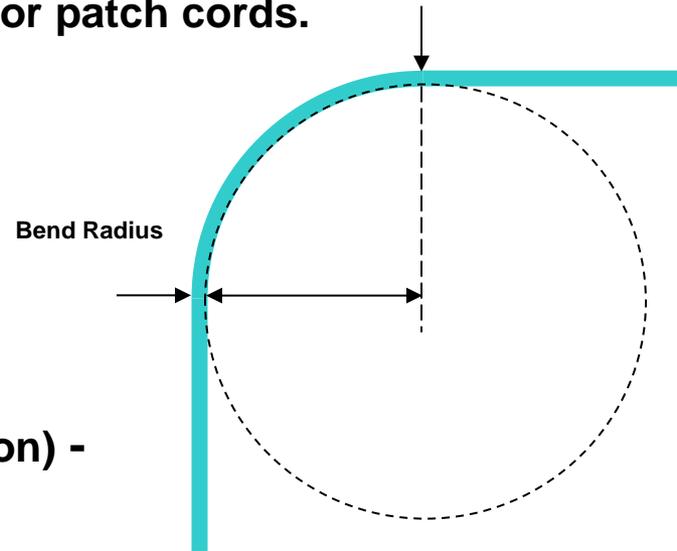
- Minimum conduit bend radius shall not be less than:
 - 6 times the internal diameter for conduit ≤ 2 " (5cm)
 - 10 times the internal diameter for conduit > 2 " (5cm) or conduit containing fiber



Cable Bend Radius

Copper

- **Minimum bend radius shall not be less than:**
 - 4 times the cable diameter for copper horizontal cable (UTP)
 - 4 times the cable diameter for shielded UTP cables
 - 1 times the cable diameter for patch cords.
 - 15 times the cable diameter for multi-pair cable.

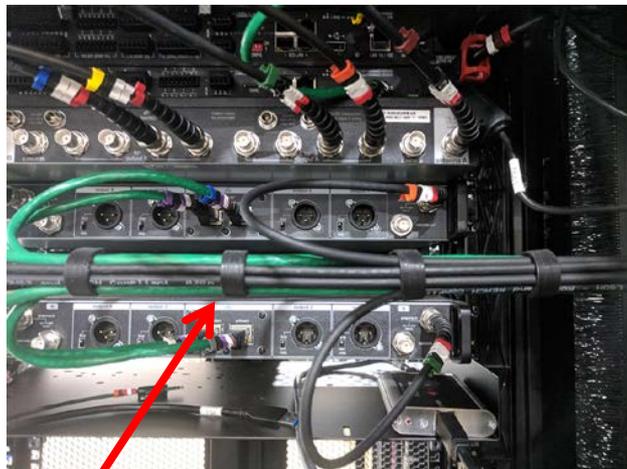


Fiber

Minimum Bend Radii While Subject to Maximum Tensile Load (During Installation) - 20 times of Outside Diameter (O.D.)

No Tensile Load (After Installation) - 10 times of Outside Diameter (O.D.)

Cable Ties - Cables



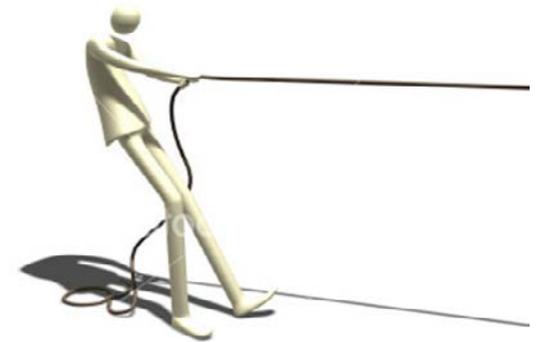
- Hook and loop shall be used on all category cables, coaxial, and fiber cables. Spacing between cable ties shall be unevenly spaced.





Pulling Tensions

- Copper - Maximum pulling tension for 4-pair horizontal UTP should not exceed 25 lb (110 N) per cable.
 - Avoid kinking of cables
 - Avoid stretching of conductors during installation
 - Avoid doing anything that changes the geometry of the twisted pairs
 - Some manufacturers offer cable that is less susceptible to damage/degradation from excessive pulling tension
- Fiber – Per MFG spec



Slack Storage

- When storing slack cables in the equipment room keep in mind the following points to avoid the resistor effect:
 - Slack of about **6 feet**
 - If slack is stored in loops, randomly place Velcro straps to avoid phasing issues
 - Ensure that loops are not tightly or symmetrically coiled
 - Store slack preferably in a “lazy-S” or figure 8 design or run back/forth on tray
 - At the station end, slack of about **12 inches**

Cabling Installation Practices

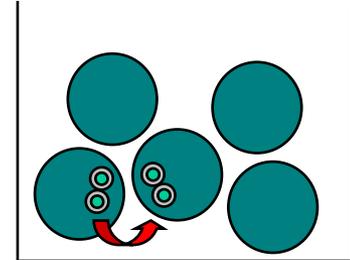
- Avoid heat, water, condensation and power
- Cables should be supported at least every 48-60"
- Cables should be free from stress
- Bundles kept to 24 cables or less, consider 12 cables - ¼" - ½" spacing between bundles
- Label all cables/outlets/ports per Infocomm F501.01:2015

Minimum separation from power

Fluorescent Lighting	>5 in. We >12 in.
Power Conduits	3 in. to 12in.
Electric Motors	48 in.
Transformers	48 in.
Temporary Lighting	6 in to 24 in.

Dressing Cables

- To dress or not to dress cables?
 - Dressing, combing and bundling of cables are terms often used in describing the quest for a neat or clean installation
 - Bundles of 12 or 24 cables or less are preferred
 - Major issue: Alien Crosstalk for 10 Gig apps
 - Alien = crosstalk noise coming from cables sharing the same pathway, and connectors in close proximity



Bundling restrictions and an LP (Limited Power) rating has been added to the NFPA70 2017

The intent is to regulate the PoE amperage/wattage while considering the cable's:

- AWG size
- Temperature rating
- Number of cables installed together or bundled.

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Valid ratings include: **0.5A**, **0.6A**, **0.7A**, 0.8A, 0.9A or 1.0A

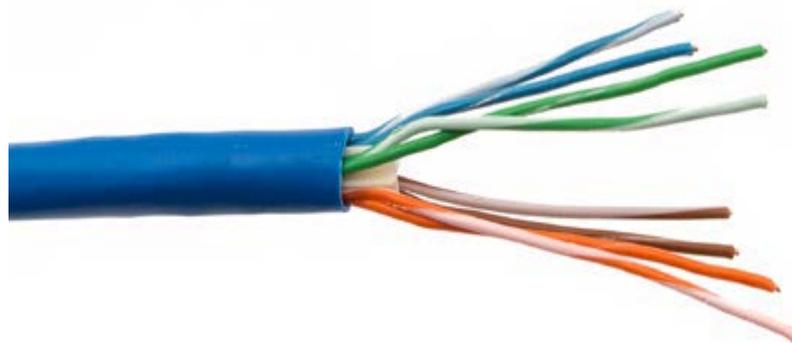
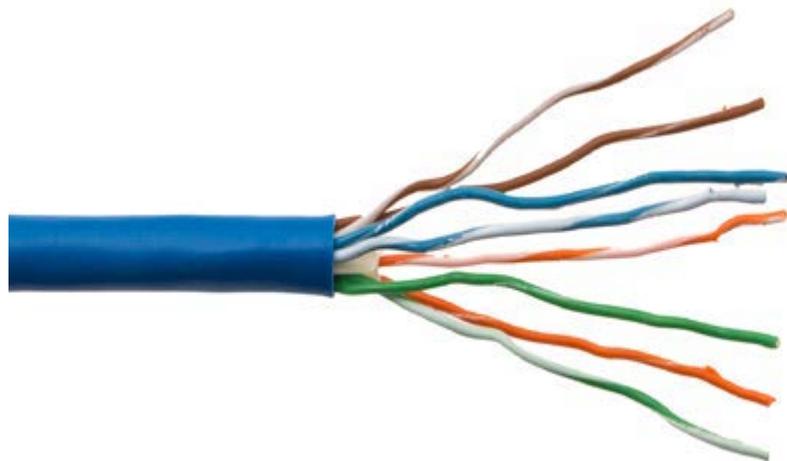


Unjacketing of Cables



- Only as much jacket as necessary should be removed when terminating cables
- Requirement imposed to:
 - Maintain twist and lay of pairs
 - Minimize separation of conductors in a pair

Untwisting the Cable Pairs



- While standards allow for ½” (13mm) of untwisting regardless of Category, preserve wire twists as closely as possible to the point of mechanical termination to ensure maximum performance.
- Follow manufacturer guidelines
 - In many cases ½” (13mm) is too much!
 - Start untwisting only before inserting the wires in the IDC
- In the event that too much untwisted pair is observed, **never re-twist!**
 - Cut off all four pairs at the point of last twist, and re-terminate.

What Does a Fiber Portfolio Look Like?

1. Field-Termination

- Field-installable Connectors & Accessories



2. Patch Panel Systems – Data Center & LAN

- Patch Panels, Frames, Cassettes, Adapter strips & Accessories



3. Pre-Term Assemblies

- Patch Cords & Trunk Assemblies

4. Workstation Outlets

- Faceplates & Inserts



5. Workstation Connectivity

- Floor Boxes & Wall boxes

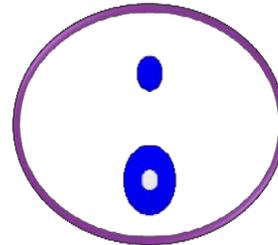
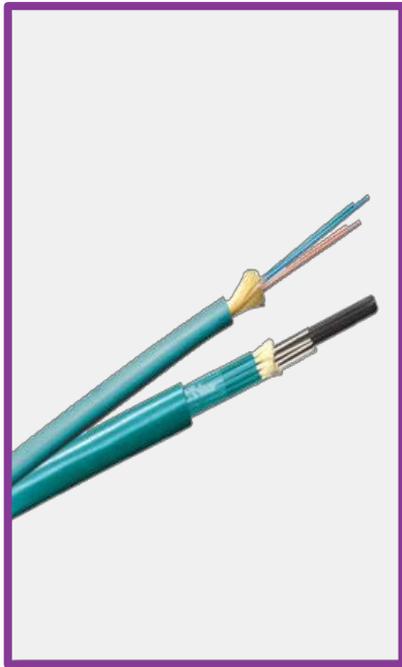


6. Optical Fiber Cable

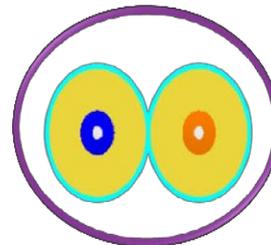
- Indoor, Indoor/Outdoor & Outdoor Cable



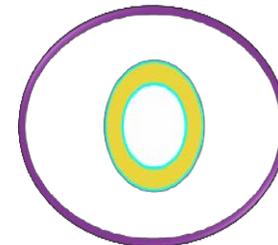
Fiber Cable



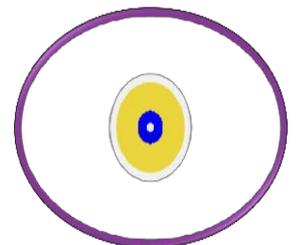
Bulk Fiber



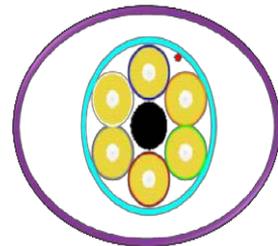
Interconnect



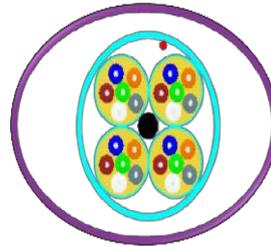
Furcation Tube



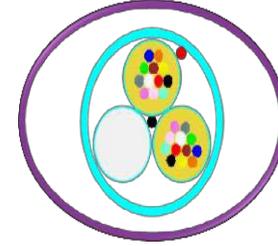
Drop



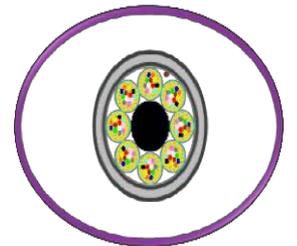
Breakout



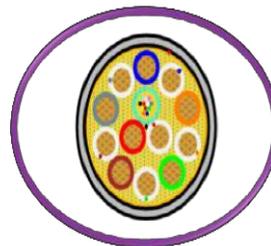
Distribution



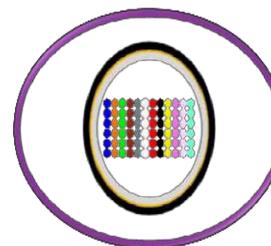
Mini-Distribution



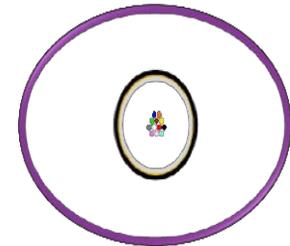
Multi Loose-Tube



Composite



Ribbon



Central Loose Tube

Interconnect Cables

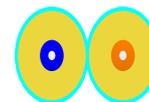


Easy to Manipulate for Day-to-Day Patching

- Small OD (2 mm-3 mm)
- Flexible Jacket (10x/15x)
- Simplex & Duplex (LC, SC, ST)
- 12f & 24f (MPO-12, MPO-24)



Simplex



Duplex
Zip



Duplex
Round

900 μm Fiber

Easy Routing within Cabinets

- Lightweight
- Low Crush, Low Tensile



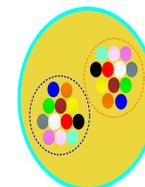
Ribbon



Duplex
Mini-Round



12-Fiber
Mini-Round



24-Fiber
Mini-Round

250 μm Fiber

Fusion – Benefits & Applications



BENEFITS

- Future proofing for high-bandwidth and high-speed transmission networks
- Reduced hardware costs versus traditional pigtails
- Robust, reliable installations for indoor and outdoor environments
- Improve first pass yield by +3%



KEY APPLICATIONS

- Enterprise Networks
- Hospitality Networks
- Passive Optical LAN

LC Splice-On Connector



Connector Colors

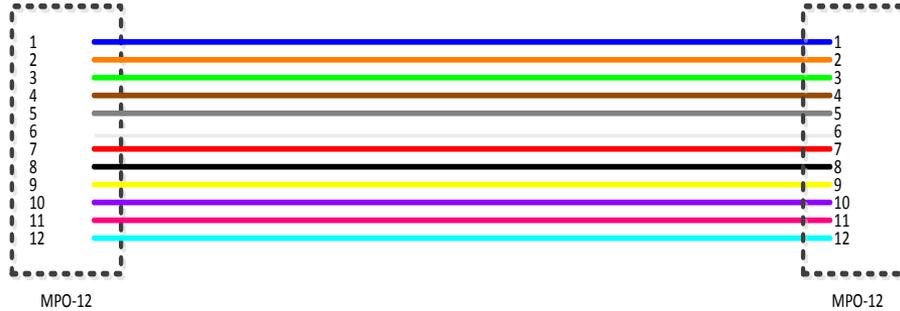


- Beige – OM1
- Black – OM2
- Aqua – OM3/OM4 – Erica Violet
- Blue – OS1/OS2
- Green – OS1/OS2/APC
– Angled Polish

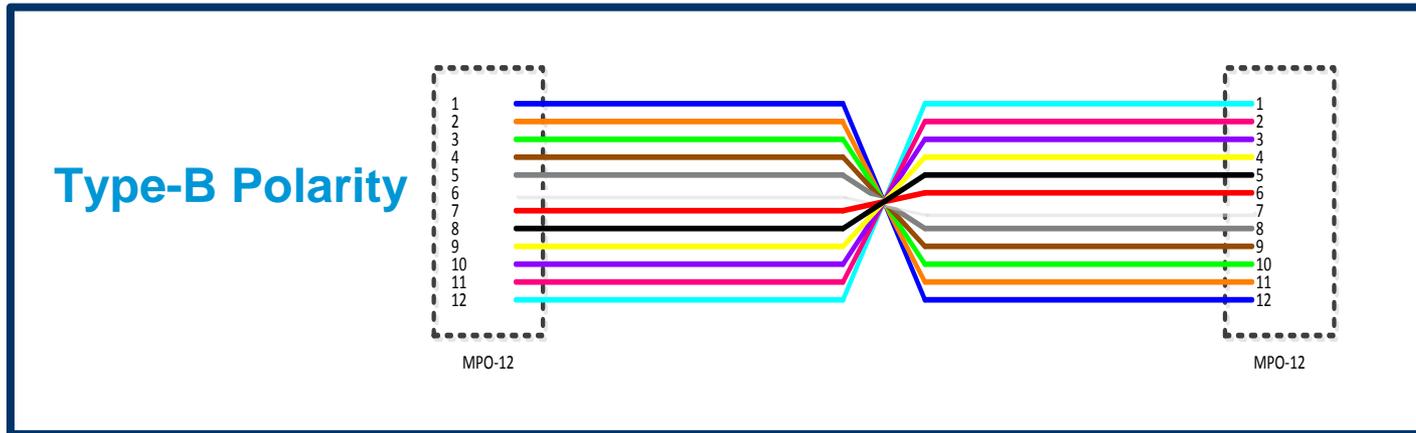


MPO Assemblies: Polarity Options

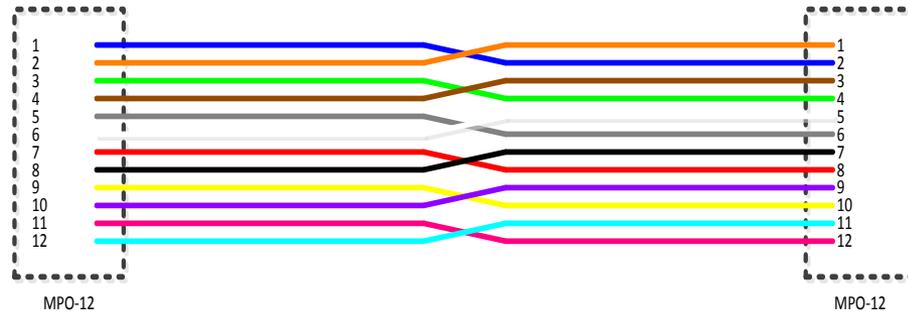
Type-A Polarity



Type-B Polarity



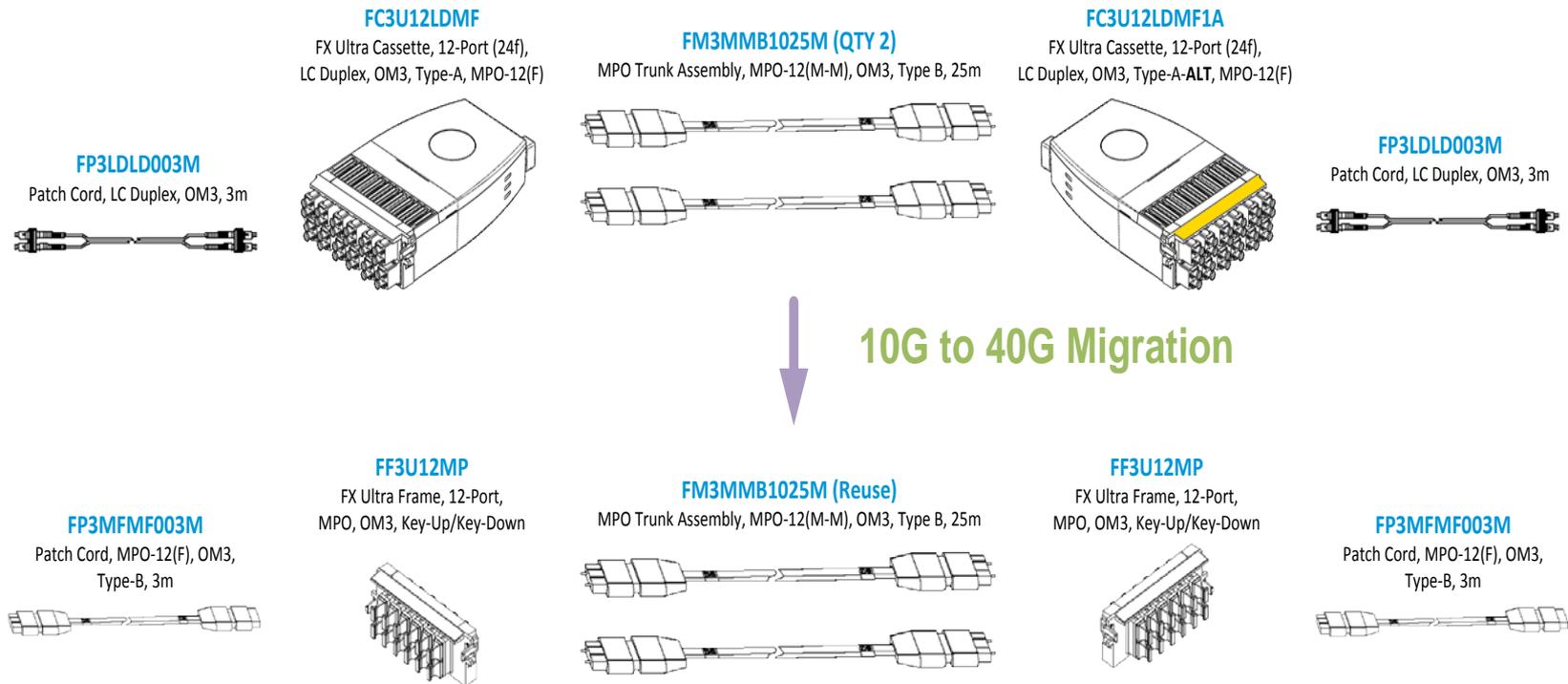
Type-C Polarity



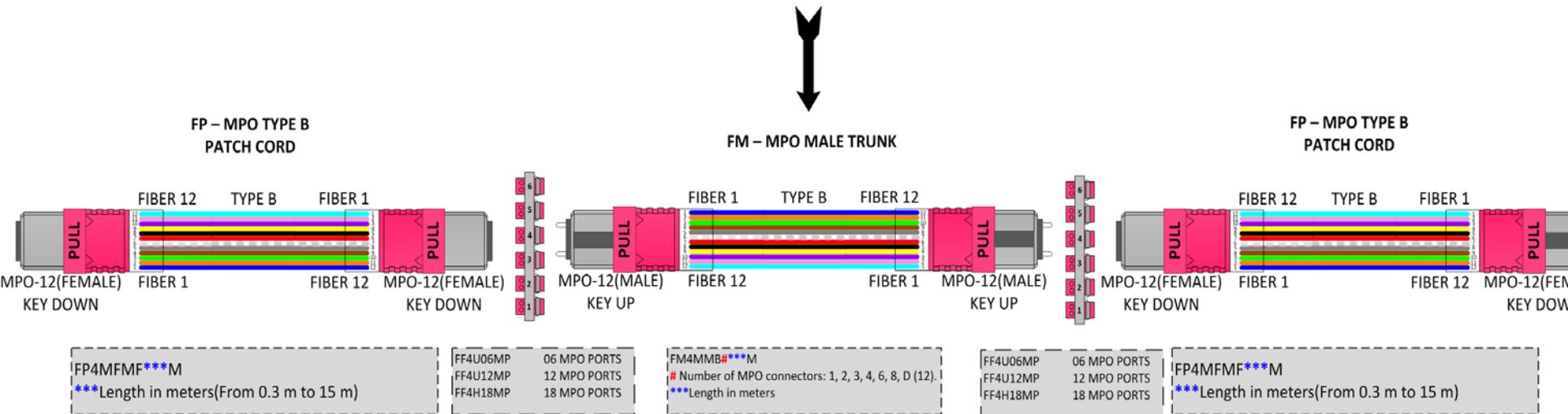
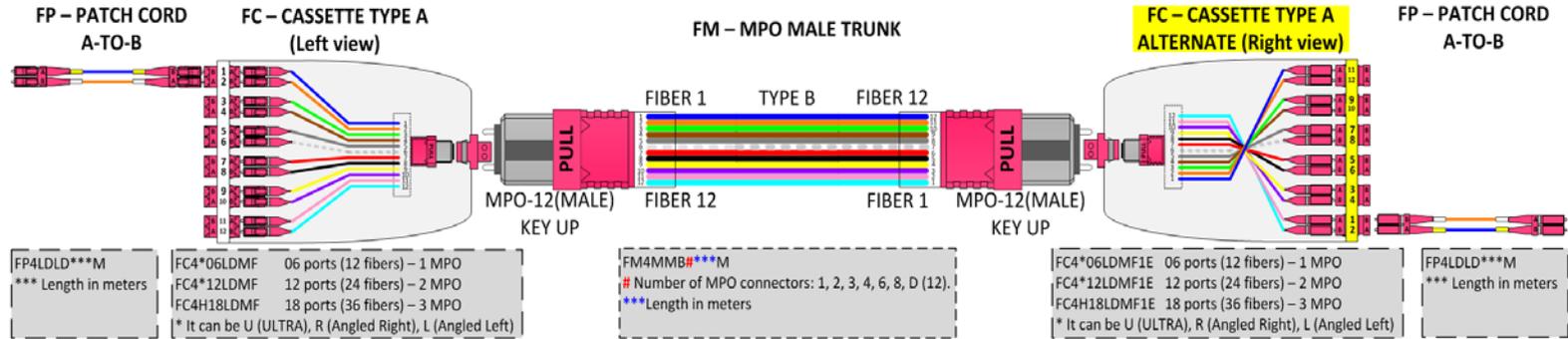
(MPO Trunks): Plan For The Future

Reuse the Trunk

- Upgrade just the Cassette / Fanout & Patch Cord



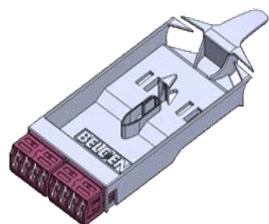
OM4 - INTERCONNECT: 10G Installation and Migration to 40G solution 2 Points of Connections – Type B



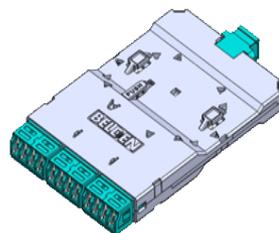
So Many Bases!

Avoid Density Loss

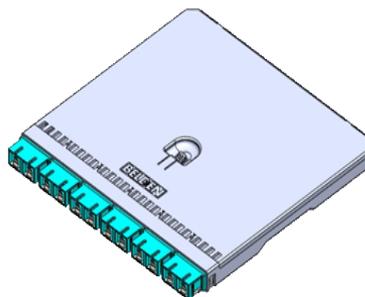
- Mix and Match Base-8 & Base-12 & Base-16



Base 8
Frame

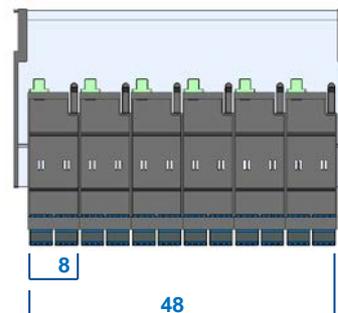


Base 12
Cassette

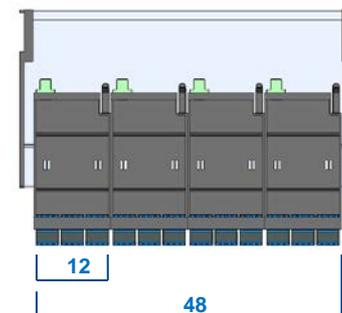


Base 16
Splice
Cassette

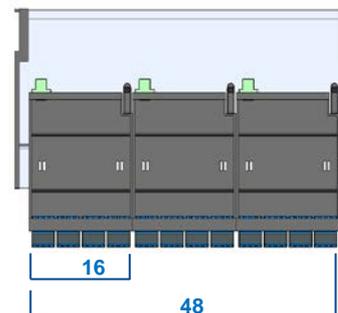
Base 8



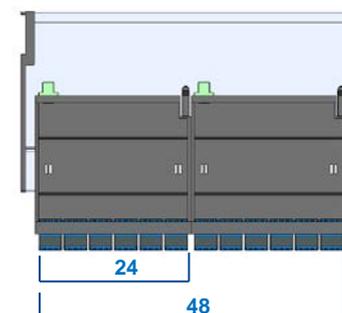
Base 12



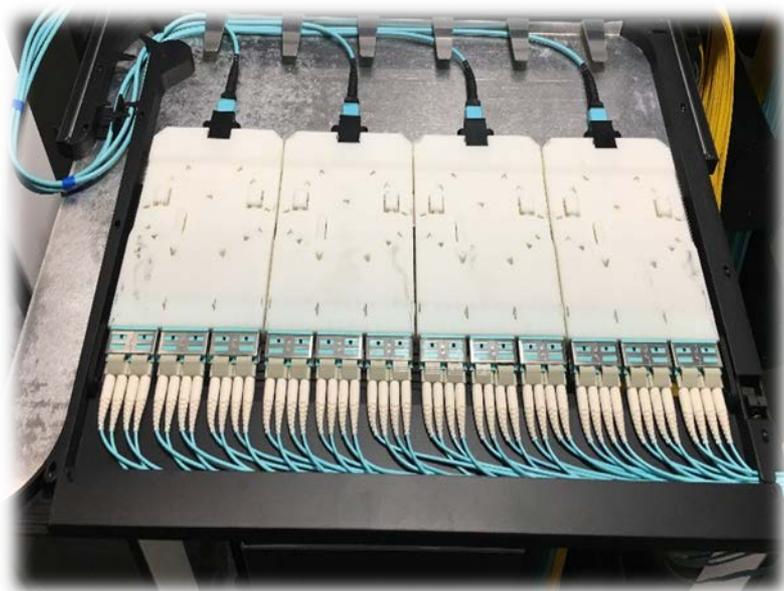
Base 16



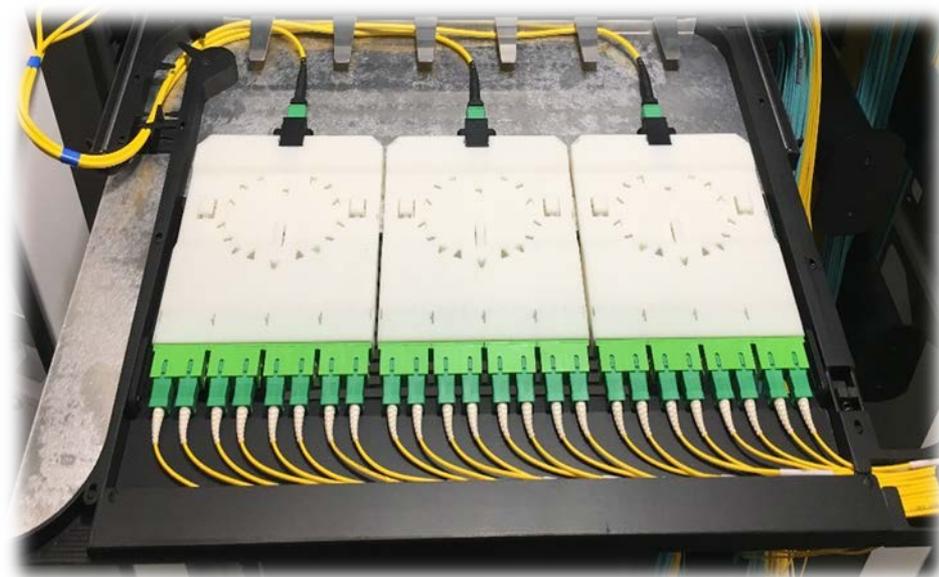
Base 24



Pre-Term Cassettes

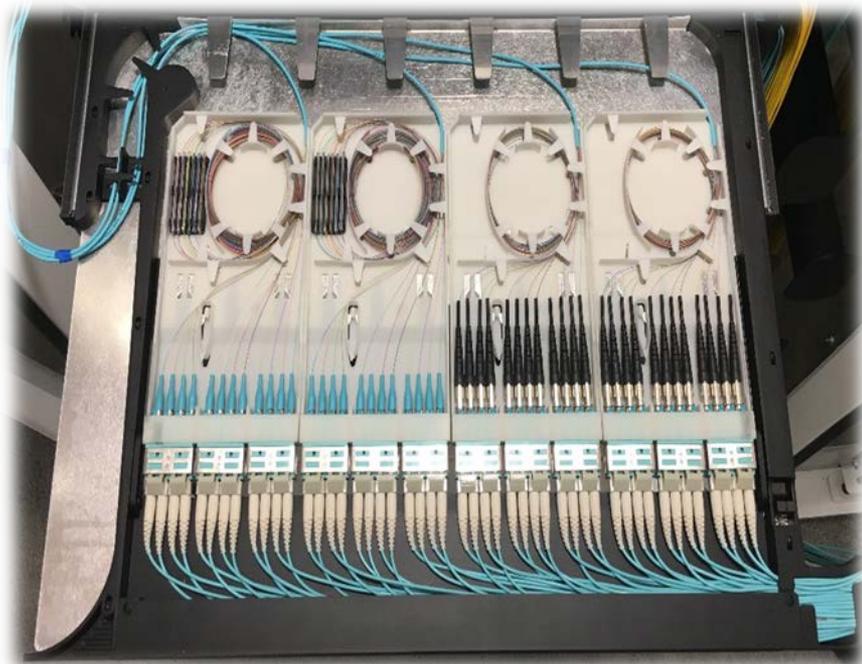


LC Base 12

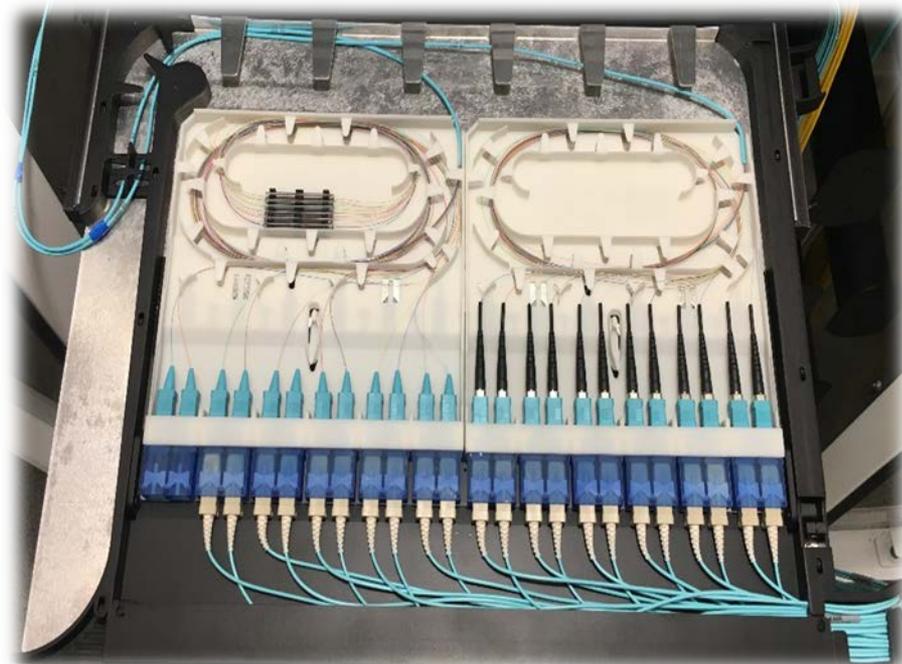


SC Base 8

Field Terminated Cassettes



LC Pigtailed (left) & LC Splice-on (right)



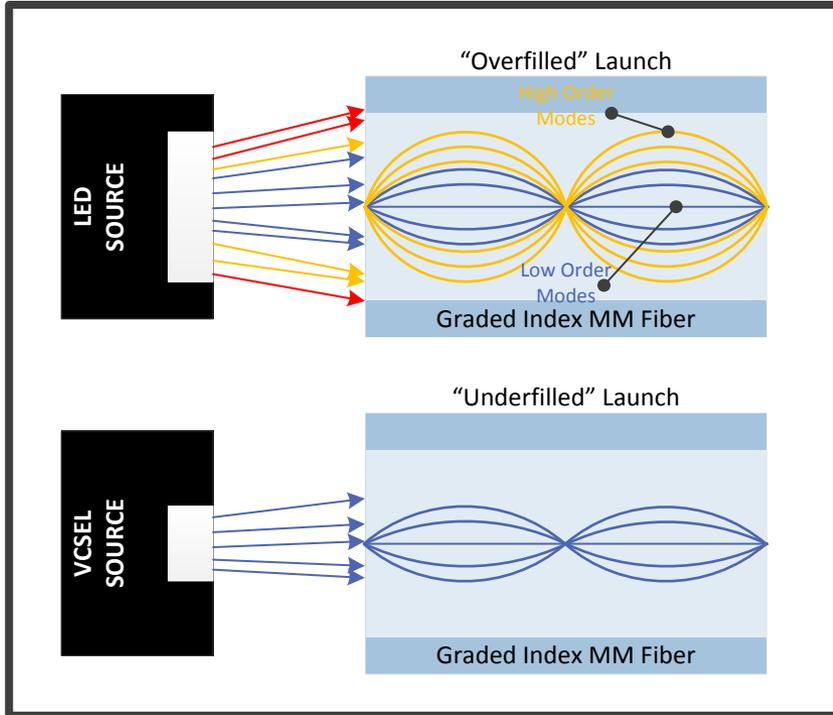
SC Pigtailed (left) & SC Splice-on (right)

General Specifications

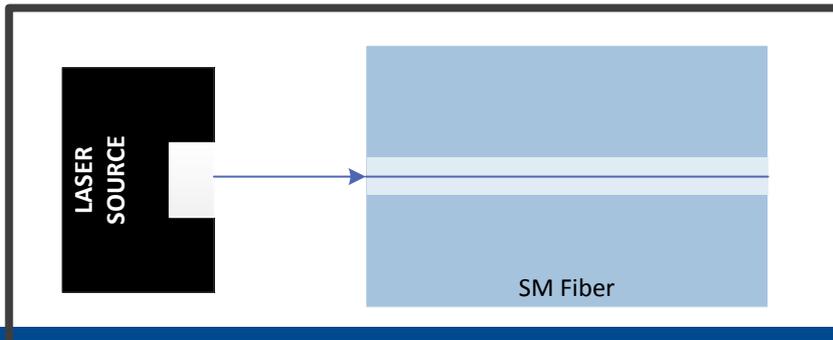
	OM1	OM2	OM3	OM4	SM
Standard	62.5/125 μm TIA/EIA-569-C.3 ISO 11801	50/125 μm TIA/EIA-569-C.3 ISO 11801	50/125 μm TIA/EIA-569-C.3 ISO 11801	50/125 μm TIA/EIA-569-C.3 ISO 11801	OS2 9/125 μm ITU G.652 ITU G.657.A1 (NEW)
Bend Sensitivity	Non-BI	BI	BI	BI	BI
Ethernet Applications	Legacy 1G: Up to 275 m	Not Recommended for New Design	1G: Up to 550 m 10G: Up to 300 m 40G: Up to 100 m 100G: Up to 100 m	10G: Up to 400 m 40G: Up to 150 m 100G: Up to 150 m	10G: Up to 40 km 40G: Up to 40 km 100G: Up to 100 km
Fibre Channel Applications	Legacy 1G: Up to 300 m	Not Recommended for New Design	4G: Up to 380 m 8G: Up to 300 m 16G: Up to 100 m	16G: Up to 125 m	4/8/16G: Up to 10 km

Getting Light in to the Fiber

MULTIMODE



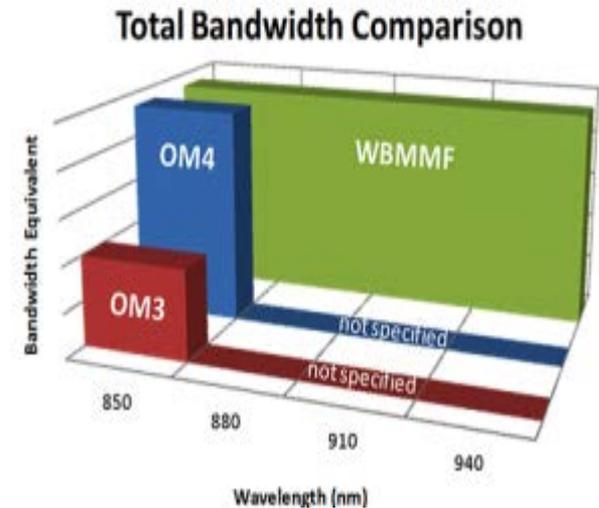
SINGLEMODE



- LED Source (MM)
 - Light Emitting Diode (LED)
 - Most cost effective
 - Overfills core
 - Lower bitrate
 - Wide spectral linewidth (TDM)
- VCSEL
 - Vertical Cavity Surface Emitting Laser (VCSEL)
 - Underfills core
 - Higher bitrate
 - Narrow spectral linewidth (FDM)
- LASER
 - Most expensive
 - Highest bitrate
 - Very narrow spectral linewidth
 - Highest power

TR42.11(&12/13) Optical Fiber Cabling (What's New)

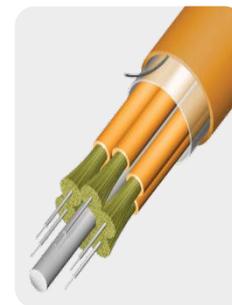
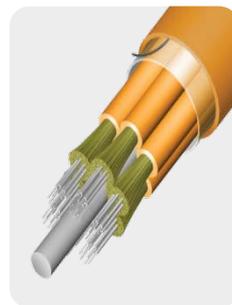
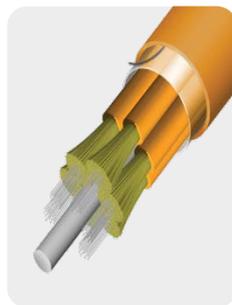
- Colour theory is a current hot topic
 - OM5 (Munsel lime)
- Om5 (lime), OS1a
- Reference grade connectors
- New CS connector type (4 lane) under consideration for Base8 applications



Proposed cable optical fibre attenuation dB/km			
	1310nm	1383nm	1550nm
OS1a	1.0	1.0	1.0
OS2	0.4	0.4	0.4



Why Select One Field-Term Trunk Cable vs. Another?

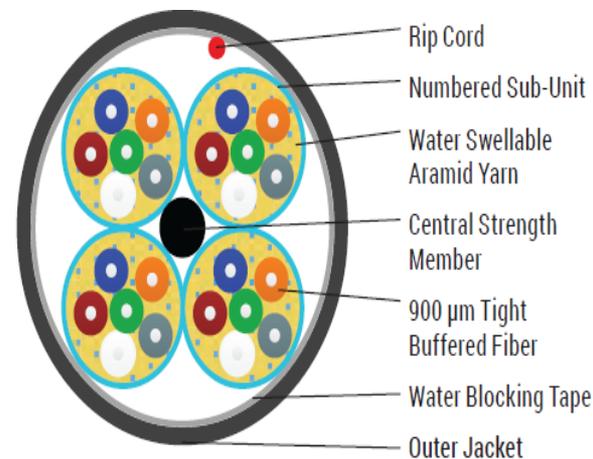


	Mini-Distribution	Distribution	Breakout
Cable Size	Smallest	Medium	Largest
Fiber Type	250 μ m	900 μ m	900 μ m
Subunits (fibers)	2 mm/3 mm (12)	4.5/5.5 mm (6/12)	2 mm/3 mm (1)
Termination Cost	\$\$\$ (LC/SC/ST) \$ (MPO)	\$	\$\$
Patch Panel Cost	\$\$ (LC/SC/ST) \$ (MPO)	\$\$	\$
40G/100G Upgrade	Yes	No	No

Indoor/Outdoor Distribution Cables

Environmental Protection

- UV Resistance
- Moisture & Fungus Resistance
- Extended Temperature Range
- Suitable for Dual use (I/O)
 - Outdoor
 - Indoor (Riser, Plenum, LSZH/Riser)
- Outdoor Installation
 - Lashed Ariel
 - In-Duct



Available for ALL Distribution Cables

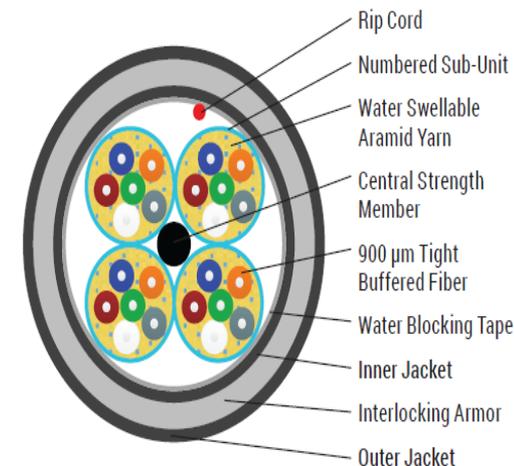
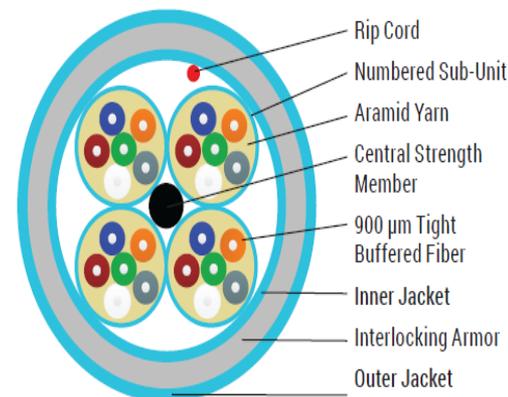
Armored Distribution Cables

900 μm Fiber for Rapid Field Termination

- Small OD Non-Unitized
- Single Pull with High Fiber Count

Rugged Cable for Tough Installs

- Eliminate Conduit with Aluminum Interlocked Armor
- Rodent Resistant
- High Crush & Tensile

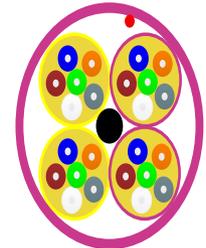


**Available on ALL Distribution
Cables (Indoor & I/O)**

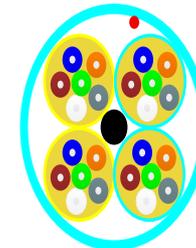
Hybrid Cable Options

Multiple Fibre Types in a Single Unitized Cable

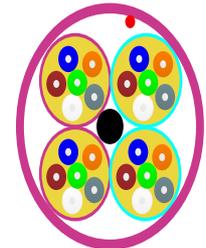
- Breakout, Distribution, (u)Mini-Distribution
- Indoor, Indoor/Outdoor
- Armored



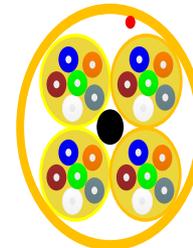
OS2/OM4



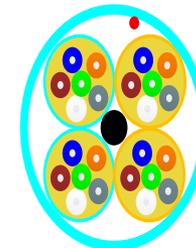
OS2/OM3



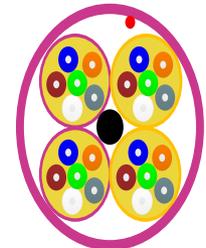
OM4/OM3



OS2/OM1



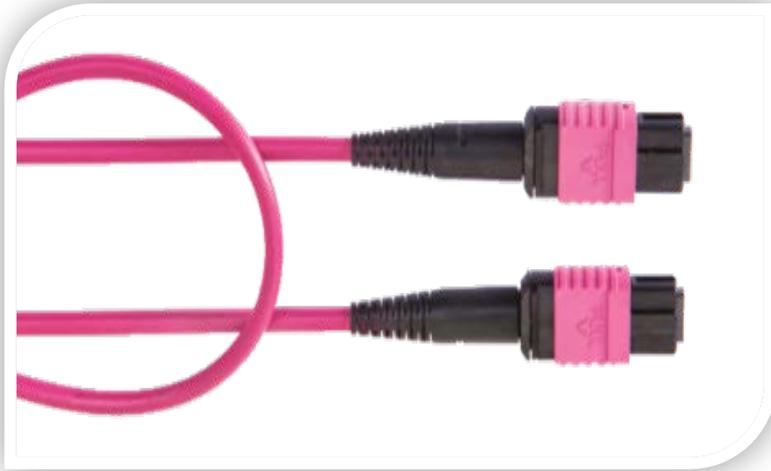
OM3/OM1



OM4/OM1

Aqua OM4 Optionally Available

Who is Erika Violet?



- AKA. Heather Violet
- European Origins
- Growing Ecosystem

OM1



OM2



OM3



OM4



SM/APC



SM

