Are You Ready to Deal With the Rapidly Changing Demands of Today's Modern Data Center?

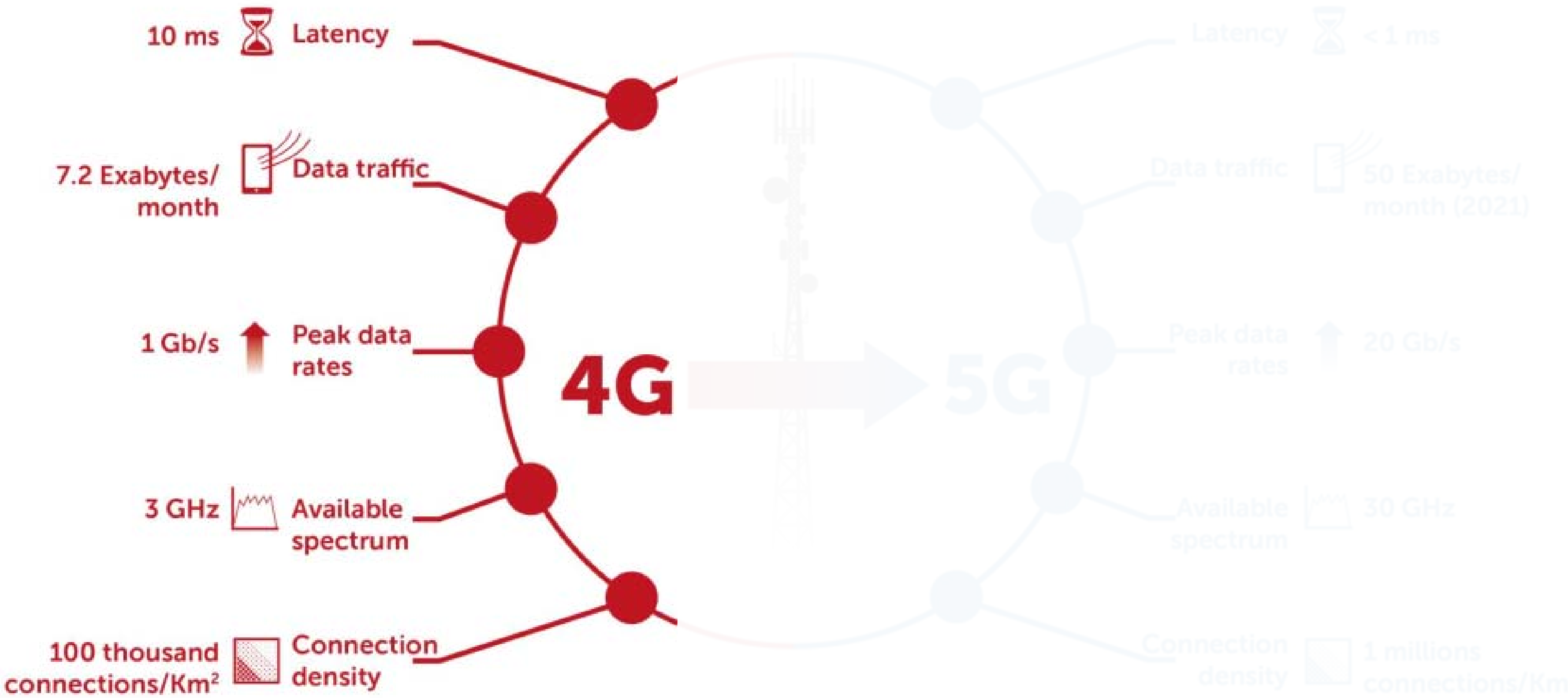
Doug Baker, Lucas Mays, Rob Gilberti

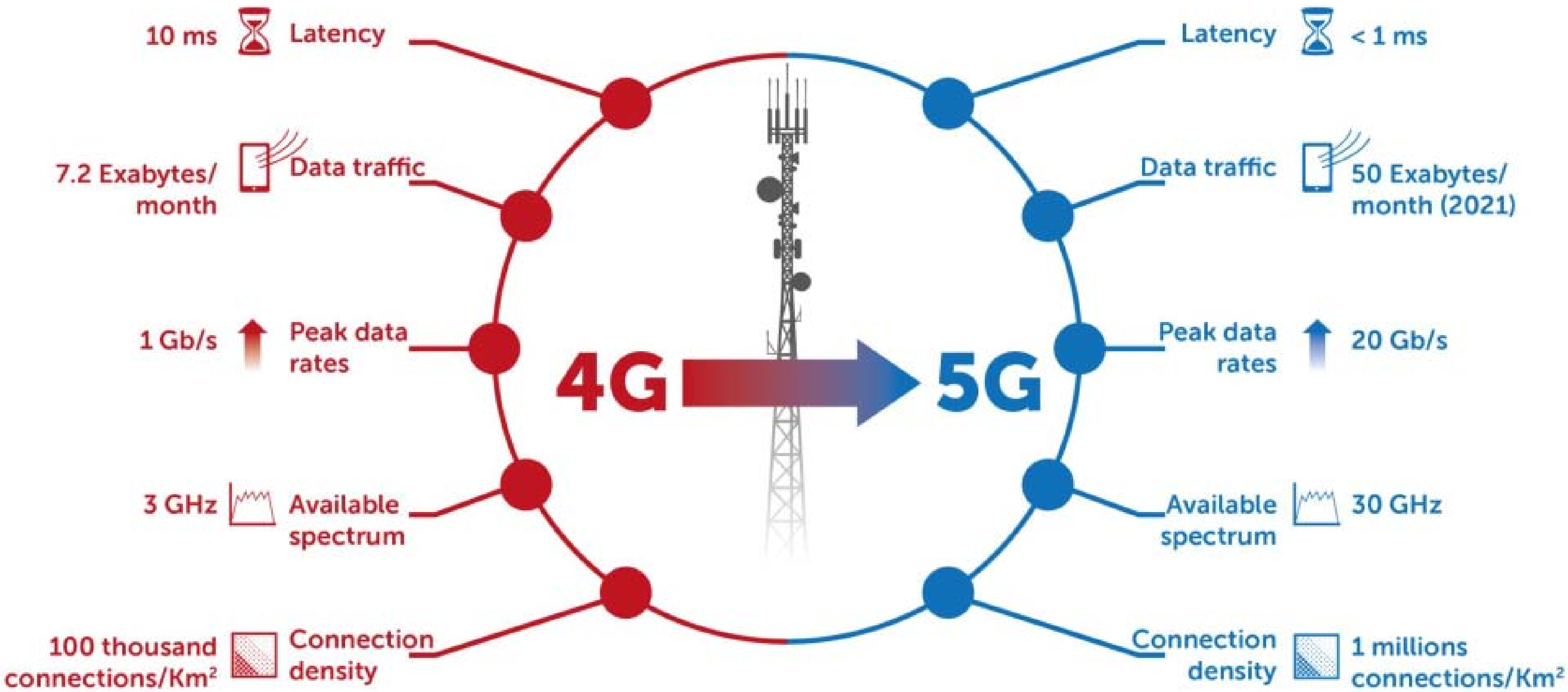
Doug Baker – 10 + years of Product Management experience in passive infrastructure and developing structured cabling solutions

Lucas Mays – experienced Application and R&D Engineer solving the challenges of field fusion splicing and network installation

Rob Gilberti – 25+ years of experience within cable manufacturing, connectivity and hardware, laser manufacturing and Test and Inspection equipment.


Smart health
Mobility/ Wi-Fi
Open data
Smart farming/ agriculture
Smart grid/ energy/ utilities
Smart manufacturing
Smart/ digital citizens
Smart buildings
Smart transportation
ART CITY COMPONEN
7:40 Call Anna
Missed Call
8:11 Simon Fet
Messages
2:05 Sara N
DATA CENTRE
(DESIGN)
END CLIENT
PRODUCTION
THE INTERNET OF THINGS


10 ms
Latency
7.2 Exabytes/
month
Data traffic
1 Gb/s
Peak data
rates
3 GHz
Available
spectrum
100 thousand
connections/Km²
Connection
density
4G
5G
Latency
< 1 ms
Data traffic
50 Exabytes/
month (2021)
Peak data
rates
20 Gb/s
Available
spectrum
30 GHz
Connection
density
1 millions
connections/Km²


10 ms
Latency
7.2 Exabytes/ month
Data traffic
1 Gb/s
Peak data rates
3 GHz
Available spectrum
100 thousand connections/Km²
Connection density
4G
5G
Latency
< 1 ms
Data traffic
50 Exabytes/ month (2021)
Peak data rates
20 Gb/s
Available spectrum
30 GHz
Connection density
1 millions connections/Km²

Central
Cloud
Data Center

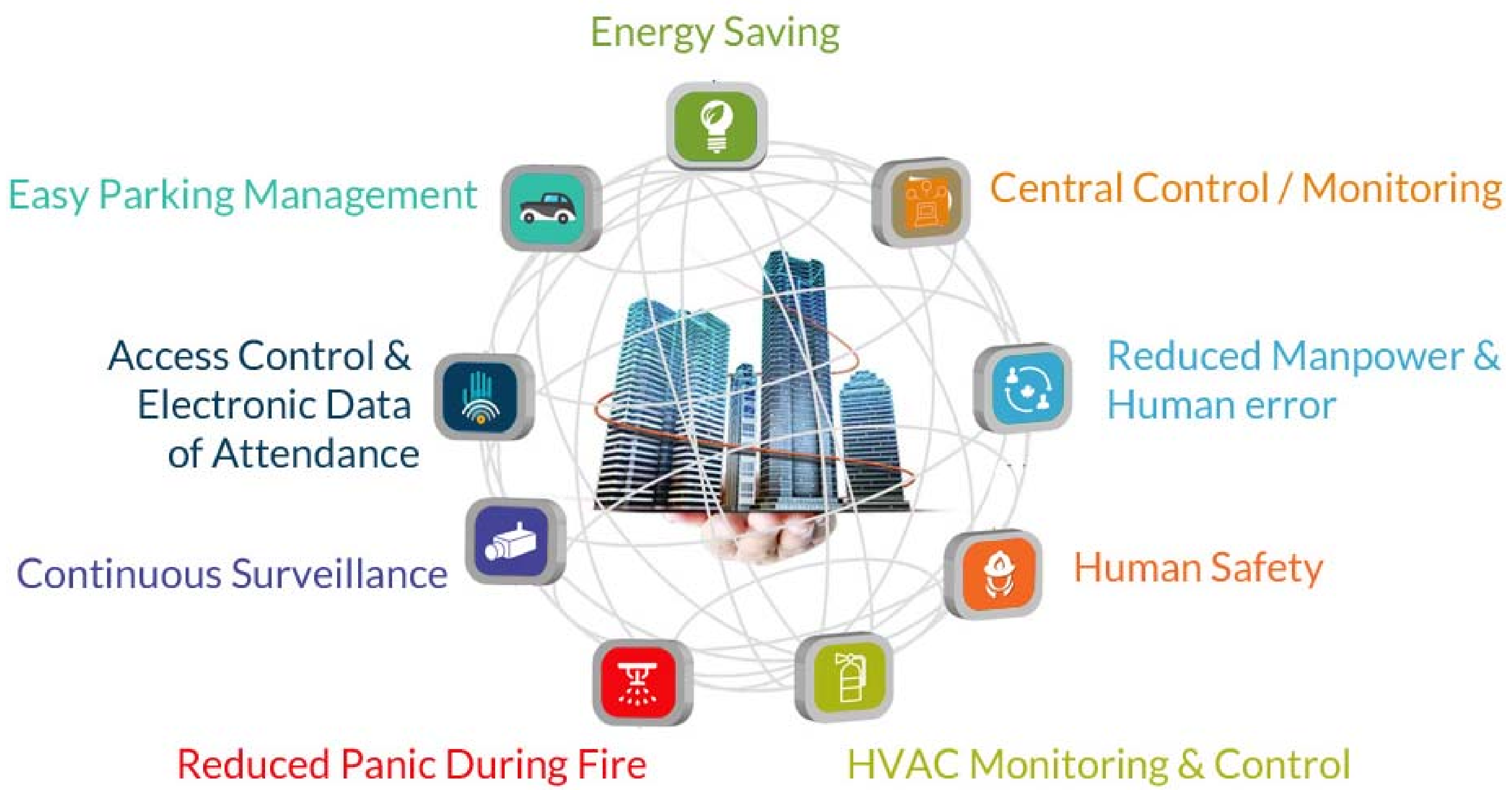
Backhaul
to the
Internet

Network
Edge
Data Center

Customer &
Application
Edge

Latency > 100ms – – – – ~ 20ms – – – – < 10ms – –

At the Heart of the Smart City

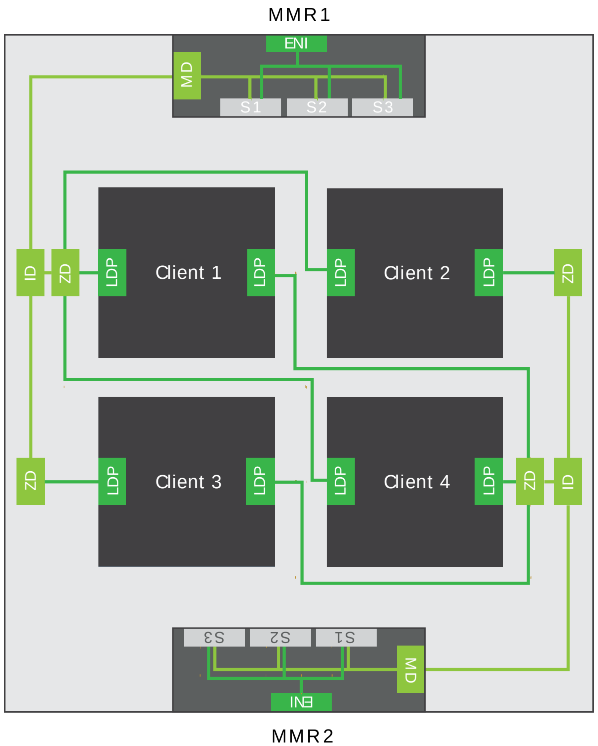


High Density Cabling

Today's challenges – Passive Cabling

- Requirements for very high density cross-connects between facilities
  - Applications for up to 6,912ct
- Requirements for high density passive in-building cross-connects
  - Configurable, Flexible, Easy to install, handle
- Low-Loss
- Ease of use, maintenance
  - Ribbon solutions reduce handling
  - Fewer splices, more efficient maintenance
- Access
- Global consistency in solutions offerings

Basic Data Center Model

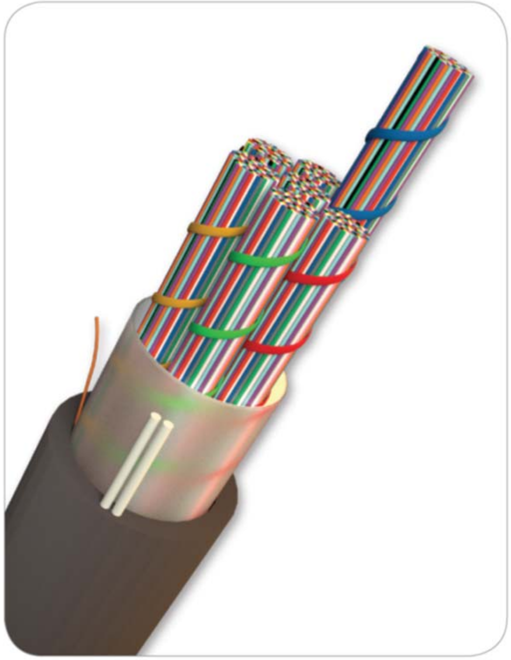


Courtesy: AFL Hyperscale

Challenge: High-Density Cross Connects

- Typically Outside-Plant (OSP) cable due to distances and conditions on-campus or between Installations.
  - Maximize Connections while minimizing infrastructure
    - Pathways, Connectivity, Installation expense

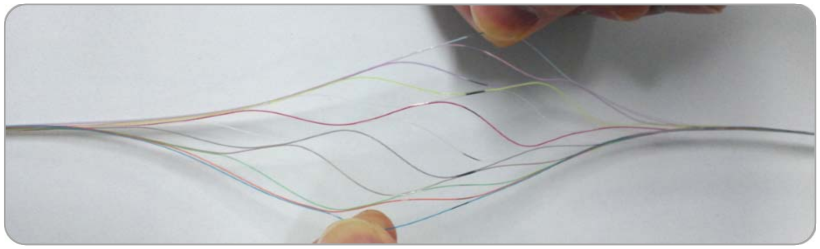
- Innovative new cable options exist that incorporate the following features:
  - Latest generation ribbons that promote Mass Fusion splicing
  - Dry-Core or Gel-Free constructions
  - Smaller Cable Diameters
  - Ease of use
    - Handling
    - Cable entry
    - Organization

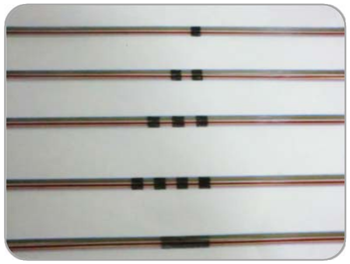


Leading Cable Characteristics

Latest Generation Ribbon

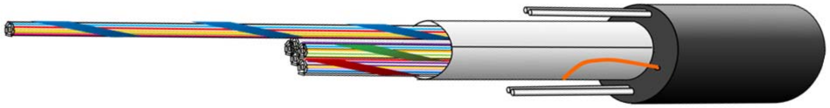
- Promotes use as Ribbon or Loose Fiber
  - Enables Mass Fusion splicing, or Individual splice connections
  - Maximizes use of space in cable core
- Clear Organization



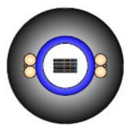
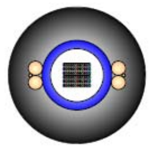
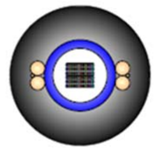
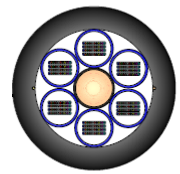
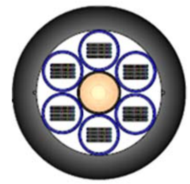
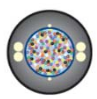
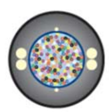
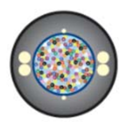
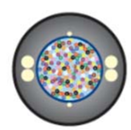
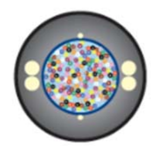
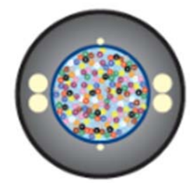


Smallest Diameters

- Maximize pathway utilization
  - High Fiber Counts



Latest Generation Ribbon Cable Size Advantage over Traditional OSP Cable Designs

	144F	288F	432F	864F	1728F	3456F
Loose Tube Cable	 16.0 mm	 18.9 mm	 21.0 mm	–	–	–
Ribbon Loose Tube Cable	 13.9 mm	 19.8 mm	 19.8 mm	 25.1 mm	 35.4 mm	–
Flexible Ribbon Cable Example	 10.5 mm	 12.0 mm	 13.5 mm	 17.5 mm	 23.0 mm	 30.0 mm

Pathway use example

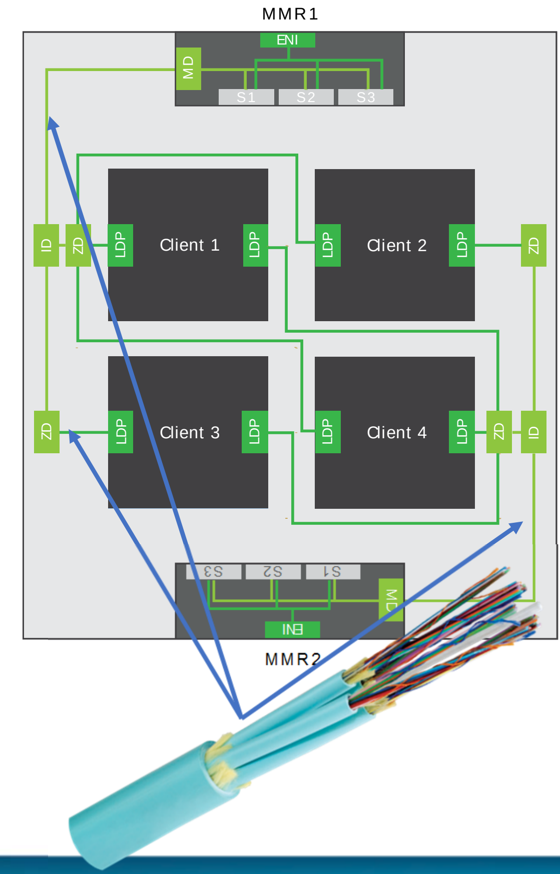
- Latest Generation Ribbon vs Conventional Loose-tube
  - Illustrates the impact of the evolution in design
  - 3 – Way, 1.25/1.50 in Microduct system measuring 3.0 in Diameter
  - 288ct Traditional Loose-Tube
  - 864ct Ribbon
    - Same density in one Microduct accomplished with 3 x 288ct in Traditional!

Challenge: In-Building Optical Cable

- Inside-Plant cabling
  - Maximize Connections while minimizing infrastructure
    - Pathways, Connectivity, Minimizing Installation expense

- Cabling options exist that incorporate the following features:
  - Latest Generation ribbons that promote Mass Fusion splicing
  - Structures that promote ease of use, installation
  - Smaller Cable Diameters
  - Maximum configurability
    - Bulk – can be managed on-site
    - Pre-terminated
      - Single-end or fully pre-terminated

Basic Data Center Model



Leading in-building cable attributes

High count backbone cabling can be installed via Splice or high-density connections

Match Cabling structure to connectivity scheme

- Available up to 1728ct
- 8, 12, 16 or 24 count sub-cable build-out

Latest Generation Ribbon (base building block)

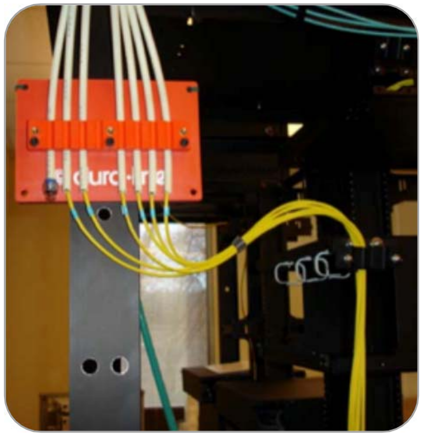
- Use as Ribbon or Loose Fiber
  - Enables Mass Fusion splicing, or Individual splice connections
  - Maximizes use of space in cable core
- Clear Organization

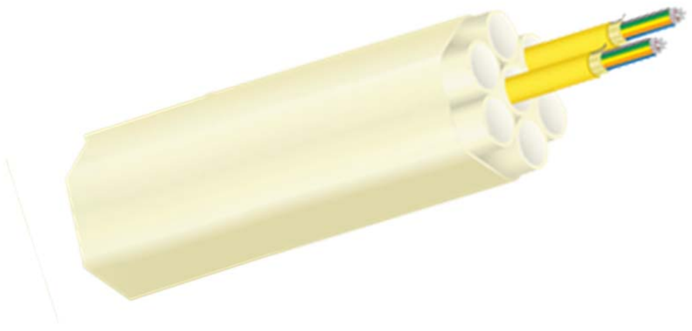
Another Option: Jetted MicroCable

Alternative to Traditional Sub-Cable style

Characterized by:

- Individual pathways
  - Enhances Security
  - Minimizes post-install access requirements
  - Configure to specific needs
  - Easy moves, adds and changes
- Air-assist installation
- Ribbon construction
  - Mass Fusion splicing





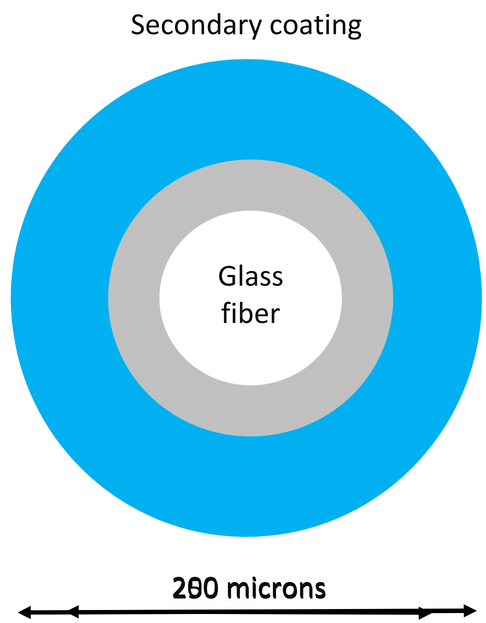
Next evolution in Density/Pathway utilization

200um Single-mode Fiber (SMF)

- ITU G.652, ITU G.657 grade, backwards compatible
  - Single Fiber and Flexible Ribbon options

- Core, Cladding dimensions match current 250um infrastructure
  - Strip, Clean, Cleave process are similar to current best-practice

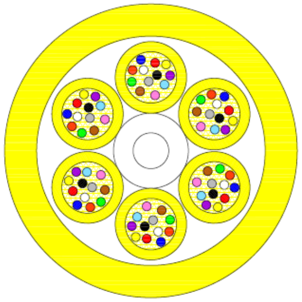
- Further reduces the impact of the passive cabling infrastructure
  - 35% reduction in fiber cross-section impacts all elements of cable design
  - Smaller cable diameters – higher density in existing or future constructions
  - Lower weight, smaller bend radii



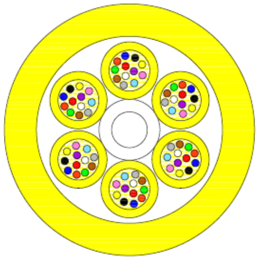
Courtesy: The Light Brigade

Next evolution in Density/Pathway utilization

- Examples of cross-sectional impact (Inside-Plant cable)

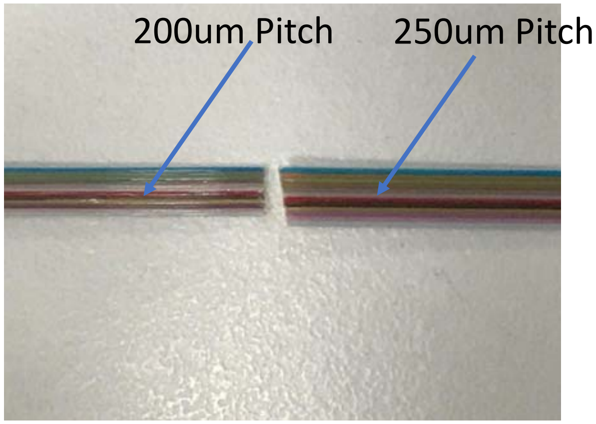


Current 72f – 8.2mm



200um 72f – 7.0mm

- Important Points to consider with 200um
  - When deploying Ribbon..
    - Look/Specify solutions that are backwards compatible
    - 250um Pitch to match standard solutions already deployed
      - Standard work processes apply
      - Little re-training required



In Summary

- Very high density optical interconnects are now possible and commonly deployed
- Technologies have evolved to support efficient, cost-effective installation techniques
  - Enhanced Mass Fusion splicing
  - Cable handling and maintenance
  - Customizable solutions (build in place)
- Structured cabling impact will continue to be reduced with deployment of 200um Single-mode solutions in Next-Gen solutions

The Fiber Management Challenge

Challenge: Managing increasing Densities and potential for Network Migration

- Increasing fiber counts in Backbone and Zone cabling
- Depending on protocol, channel counts are increasing leading to increased optical fiber densities
- Migration to increased transmission rates drives configuration changes of structured cabling to meet performance requirements
  - Especially when deploying Multimode fiber (MMF)

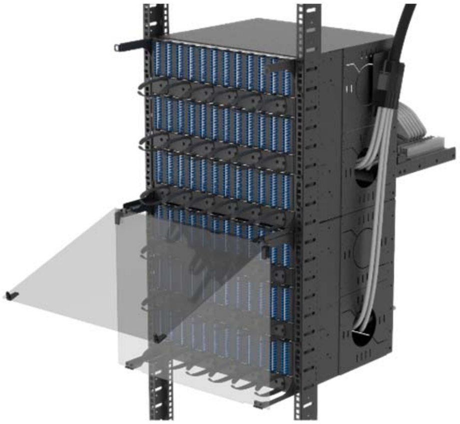
Challenge: High Density Connectivity

Entry and Backbone Cabling – How to deal with all the inbound fiber?

6,912ct Wall/Rack Mount Splice

18,432F Splice Cabinet

Dedicated Patch and Splice



Terminated Panels –
Splice at Entry Point

Example application

ENTRY

Wall-mount or rack-mount application

1,728 ct OSP Cable
- Ribbon construction

6 x 288 ct In-Building trunk cables

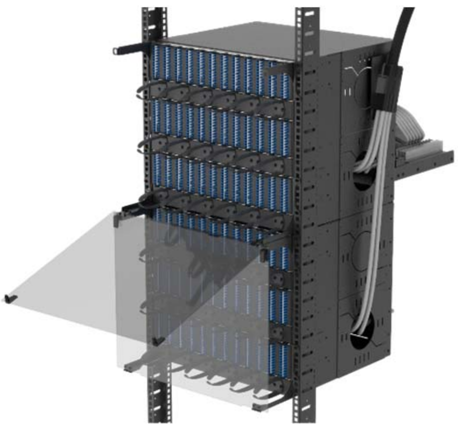
144 ct Ribbon Splice Trays

2RU 288 ct Panels
- Can be factory built, field spliced or built on-site

Challenge: High Density Connectivity

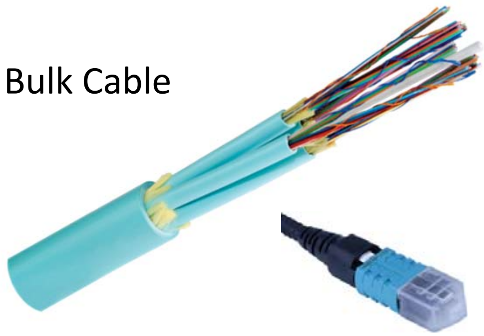
Backbone and Zone Cabling – How to deal with all the fiber?

Dedicated Patch and Splice



Pre-terminated Cabling

Build in-place MPO Trunks



Challenges impacting Passive Connectivity

- Protect investments in infrastructure against Future needs
  - Base 8, Base 12 or Base 24 Configurations
    - Can my infrastructure be configured to account for changes?
  - Maximize use of floor/rack space while enhancing ease of maintenance
  - Select MMF or SMF – this impacts structured cabling selection

- Work to minimize network loss between interconnections to maximize performance
  - Select Low-Loss connectors
  - Consider Splice vs Connected links

Multimode vs single-mode fiber cabling is dependent on the type of Data Center, link lengths, and expected bit rates

Enterprise	**Hyperscale**
• 1GbE to 10GbE to 40GbE	• 25GbE to 100GbE and beyond
• Up to 150 meters	• 500 meters to 2 km
• Multimode meets most needs	• Single-mode meets the current needs, and can meet future requirements

• Parallel optics to meet increased bit rates
  • MPO connectors
	• Increase serial speed to 100GbE+ and parallel speed to 1TbE
	  • MPO

• Shortwave wavelength division multiplexing (SWDM) with OM5 presents new growth path	• Course and Dense Wavelength Division Multiplexing (CWDM and DWDM) • Duplex LCs

Standards Based Data Rate Migration Path to 400GbE on MMF

Change cable assemblies?

Most likely →
Not required →

IEEE 802.3 Link Distance (meters)

Multimode Fiber Type	10GbE	40GbE		100GbE		400GbE*	
OM1	33 m						
OM2	82 m						
OM3	300 m	100 m	(SR4 4x10G)	100 m 70 m	(SR10 10x10G) (SR4 4 x 25G)	70 m	(SR16: 16x25G)
OM4	400 m	150 m	(SR4 4x10G)	150 m 100 m 100 m	(SR10 10x10G) (SR4 4 x 25G) (SR2 2 x 50G)	100 m XX	(SR16: 16x25G) (SR4: 4x100G)*
OM5 **	400 m	150 m	(SR4 4x10G)	150 m 100 m	(SR10 10x10G) (SR4 4 x 25G)	100 m XX	(SR16: 16x25G) (SR4: 4x100G)*

* Future

** OM5 WBMMF (wideband multimode fiber) ANSI/TIA-492AAAE .

Multimode Migration Path in Data Centers 40 GbE to 100 GbE (using 25 GbE Laneways)

- 100 GbE (4 x 25 GbE parallel optics)
  - OM3 VCSEL 70 meters 8 Fibers
  - OM4 VCSEL 100 meters 8 Fibers

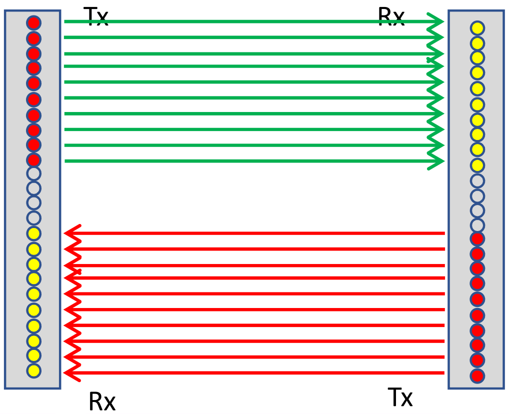
Replace transceivers, but may not need to replace cable assemblies

Multimode Migration Path in Data Centers
40 GbE to 100 GbE (using 10 GbE Laneways)

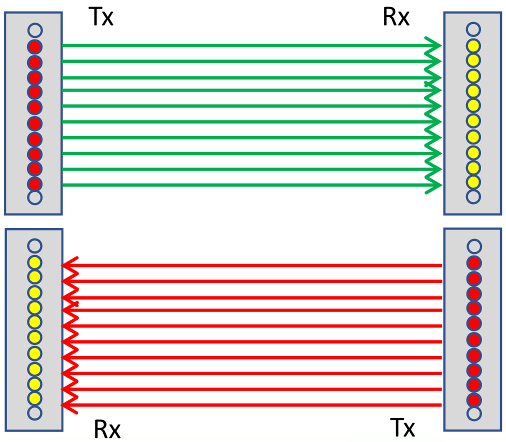
- 100 GbE (10 x 10 GbE parallel optics) – 1st generation
  - OM3 VCSEL 100 meters 20 Fibers
  - OM4 VCSEL 150 meters 20 Fibers

Replace transceivers and cable assemblies

24 Fiber MPO



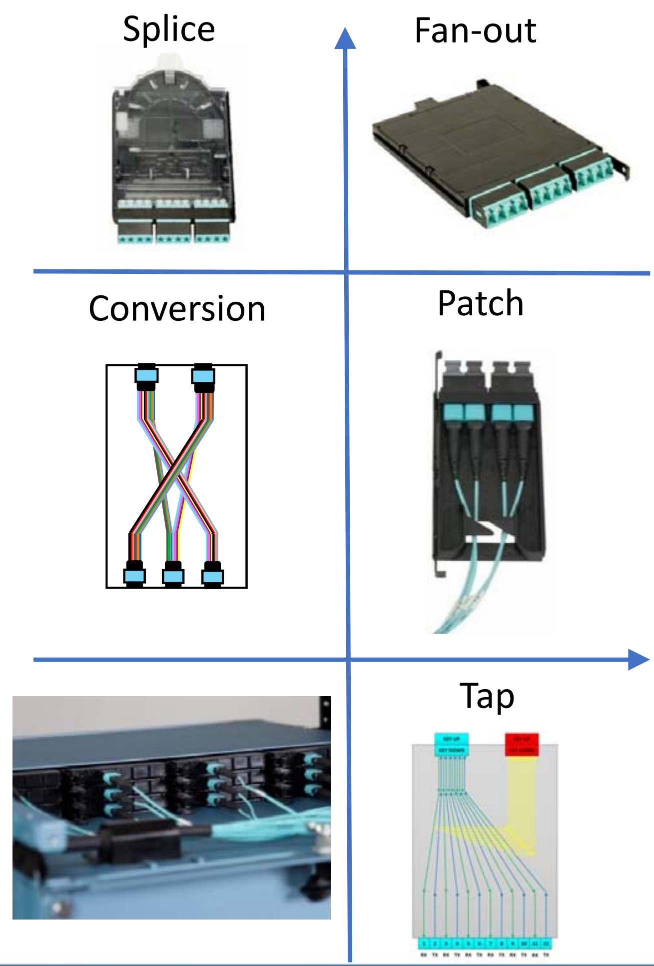
2 x 12 Fiber MPO



Leading Panel Technologies to ease migration

- Built around Cassette/Module framework
  - Base 8, Base 12 or Base 24 Elements
- Supports migration when changes are required
  - Drive to utilize existing cabling infrastructure
  - Interchangeable components
- Maximize flexibility within the Panel system
- Ease of access, Front or Rear of panel

Typical Cassette Options



Leading Backbone and Patch Cord Attributes

Trunks

- Small diameter constructions supporting Base 8, 12 or 24 frameworks
  - Commonly referenced as Micro Cable
  - Ribbon and Flexible ribbon may be selection of choice
- Engineered to support Cassette/Module conversion
- Terminated with Gender and Polarity reversible MPO/MTP® connectors

MPO/MTP® terminated Trunk

Patch Cord

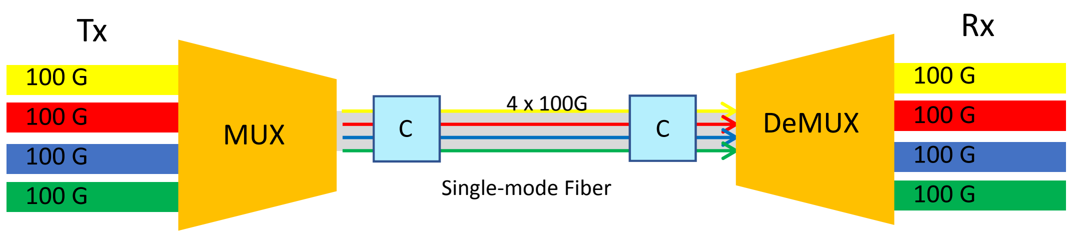
- Small diameter construction
- Terminated with Reversible Connectors
- Enhanced handling with push/pull features

Uniboot terminated Patch Cord

What’s Next – Enhances need for modularity

- Increasing panel density
  - Small Form factor connectors (2x, 4x LC Densities)
    - Supports growth of transmission lane requirements
    - Reduces physical impact

- Growth of Multiplexing in the Data Center to achieve targeted Bit rates 400GbE or Greater
  - Both MMF (OM5) and SMF

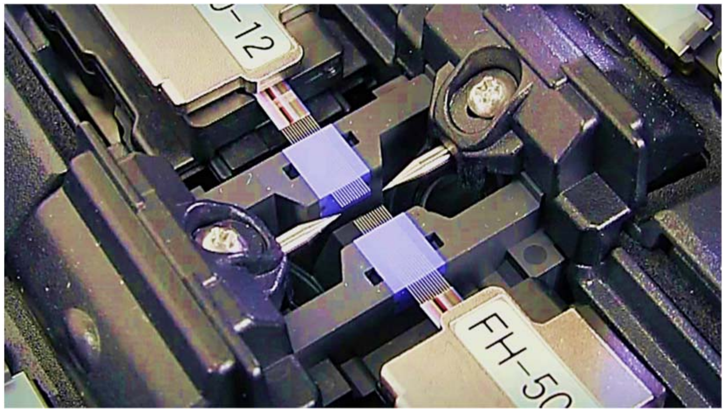


Low Loss, Rapid Splicing – What Modern Data Centers Demand

Lucas Mays

Rapid Splicing = Mass Fusion Splicing

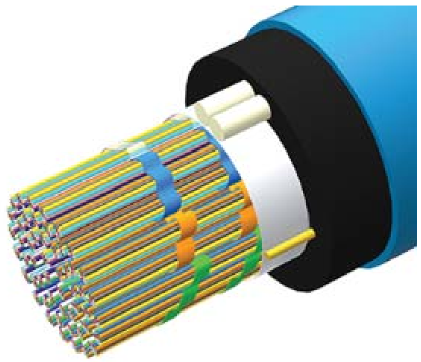
- Mass Fusion Splicing
  - Any time you are preparing and splicing multiple fibers at a single time - range is from 2 to 12



- Most commonly used with 12 fiber ribbons

Rapid Splicing = Mass Fusion Splicing

- Labor and time savings from Mass Fusion splicing are <u>HUGE</u>
  - Recent internal study estimates 87% reduction in splice time
- As fiber counts increase, single fiber splicing becomes unrealistic



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- Bottom Line: Reduce labor cost and turn-up time with Mass Fusion

Mass Fusion is Low Loss Capable

- Modern day fiber is friendly to low loss even when Mass Fusion spliced

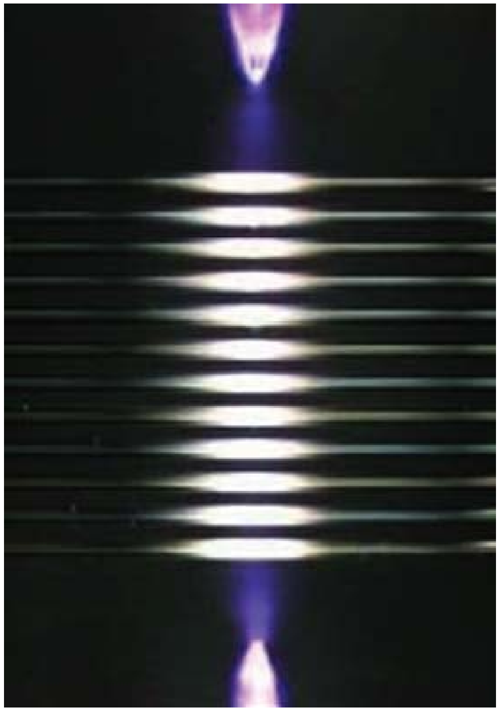
Fiber Combination	Average Splice Loss (dB)	Standard Deviation	Maximum Splice Loss (dB)	Minimum Splice Loss (dB)
G.657 #1 to G.657 #2	0.03	0.014	0.07	0.00
G.657 #1 to G.652.C	0.02	0.019	0.13	0.00
G.657 #1 to G.652.D	0.02	0.014	0.05	0.00
G.657 #2 to G.652.C	0.03	0.013	0.07	0.00
G.657 #2 to G.652.D	0.02	0.017	0.08	0.00

Reference:
David W. Mansperger, Douglas M. Duke, Lucas C. Mays, "Mass Fusion Splicing of Dissimilar Fibers" Proceedings of the 67th IWCS, 2018

- However, achieving low loss splices hinges on a few key subjects

Low Loss – What it Takes

- A mass fusion splice is not a trivial process
  - Maintaining consistency over thousands of arcs even less so
- Reputable splicer is recommended as a baseline for continued quality ribbon splices
- Arc consistency is under your control
  - If not maintained, splice quality suffers
  - Adhere to manufacturer's guidance on electrode replacements and arc calibrations

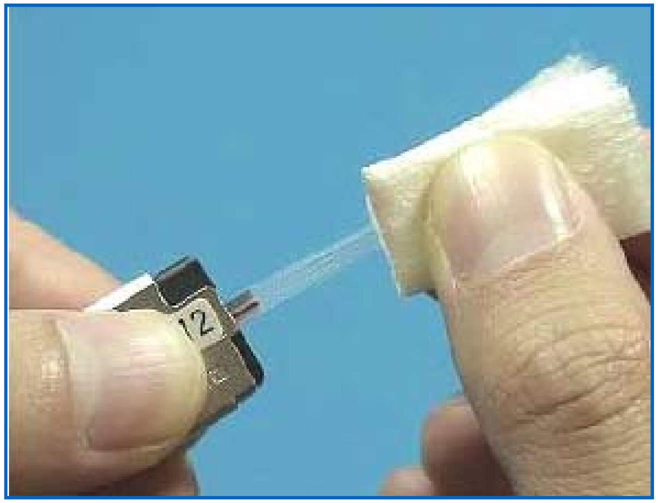


Low Loss – What it Takes

- Three major factors affect low loss capability – a.k.a. splice quality
  1) Fiber quality – as it relates to core/cladding concentricity
     a. Your cable supplier will help here
  2) Arc consistency
  3) Ribbon preparation
- If you can choose your fiber – choose high quality glass
  - It has implications beyond splicing
- If not, ribbon prep and arc consistency are the only factors you control

Low Loss – What it Takes

- Ribbon preparation requires ***consistent precision*** for quality splices
  - I.e. - continual high quality ribbon stripping, cleaning, and cleaving
  - This becomes increasingly challenging when splicing high fiber counts
- #1 – Follow manufacturer's operation instructions
- Major pain points that hinder consistent precision
  1) Cleanliness
  2) Equipment ergonomics
  3) Cleaver blade management

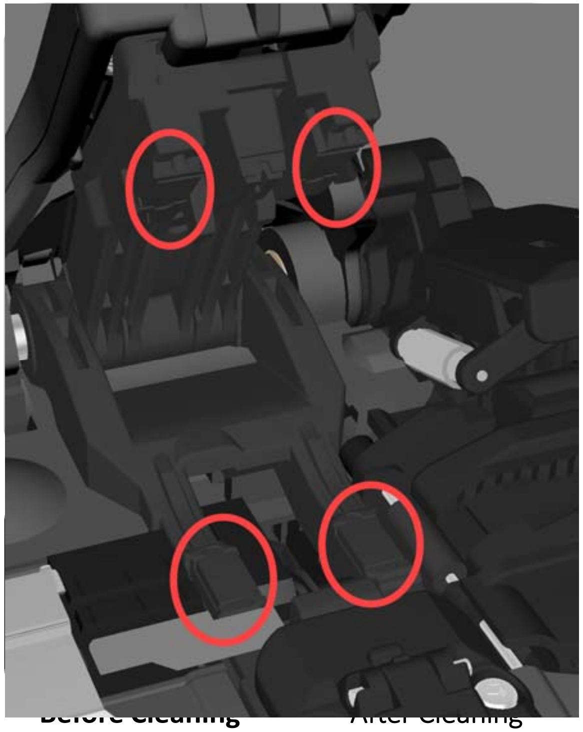


Pain (Points) Management – Cleanliness

- Mass Fusion Cleanliness – In General
  - Higher importance
  - Requires more diligence
  - Different techniques and processes
- Thermal Stripper cleanliness management
  - Particularly problematic with collapsible ribbons
  - Use a toothbrush to remove broken down coating

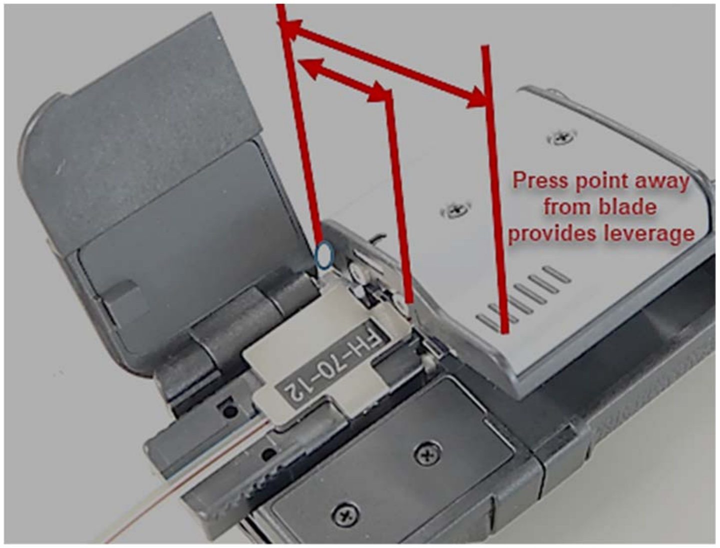
Pain (Points) Management – Cleanliness

- Splicer v-grooves require periodic cleaning at minimum
  - Or when large pre-splice offsets appear and re-prepping the ribbon does not resolve
  - Special kits exists for Mass Fusion v-groove cleaning
  - Absolutely a requirement for quality work
- Fiber holders and cleaver clamp pads also need to be cleaned occasionally
  - Especially if proper fiber cleaning is not observed
  - Use lint-free cotton swab and alcohol to clean



Pain (Points) Management – Ergonomics

- Ribbon fiber preparation consists of several manual processes
- After 288 or more cycles, these repeated motions can wear down operator hands
  - Highest contributors are thermal stripping and cleaning
- Pay attention to and ask about ribbon prep tool ergonomics – some are more friendly than others

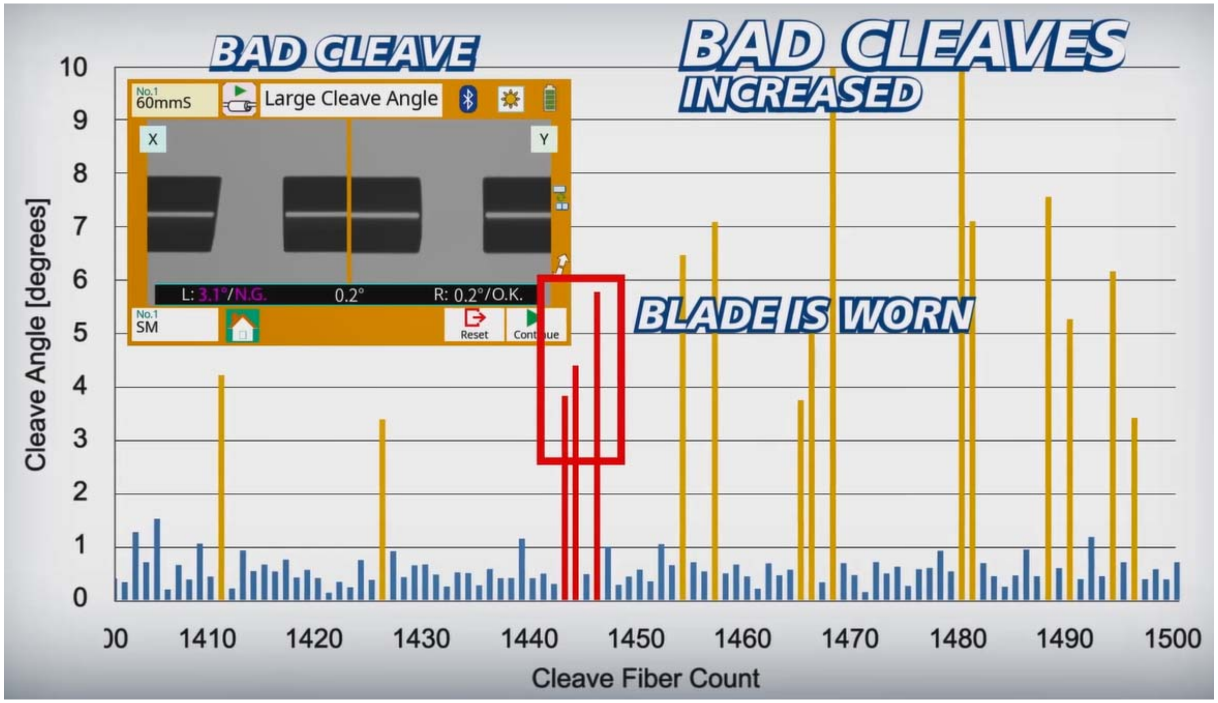


Pain (Points) Management – Cleaver Blade

- Largely underrated as a key factor in consistent low loss splices
- Some inductive reasoning to justify the importance
  - Good blade positions = good cleaves
  - Worn blade positions = bad cleaves
  - Good cleaves = good splices and bad cleaves = bad splices
  - Therefore, good positions = good splices and bad positions = bad splices
- Track your blade positions to maintain using a good one
  - You will better maintain quality splices and save time from rework

Pain (Points) Management – Cleaver Blade

- How do I know when a blade position is worn?



Pain (Points) Management – Cleaver Blade

- Difficult to manage with traditional cleavers and splicers
- Varying solutions exist to manage blade positions – below shows an automated example

Blade Management

No.	Blade Height		
	Low	Middle	High
1	1220	1453	0
2	1033	1157	0
3	844	1640	0
4	1145	1969	0
5	1193	1461	0
6	1993	1400	0
7	1898	1233	0
8	793	1130	0
9	854	1677	0
10	1180	1130	0
11	1911	453	0
12	841	0	0
13	1887	0	0
14	1483	0	0
15	1369	0	0
16	1369	0	0

▲▼+↵ Blade Rotation
ESC Exit

In Summary

- Fast-paced, low loss installs to meet today's Data Center demands requires
  1) Mass Fusion splicing instead of single fiber splicing
  2) Low loss splices to meet loss budget requirements
     a. Follow manufacturer's operation instructions of your equipment
     b. Choose high quality fiber if possible
     c. Start with quality splicer and maintain arc calibrations
     d. Consistent precision in ribbon preparation
        i. Address major pain points

Clean for Success

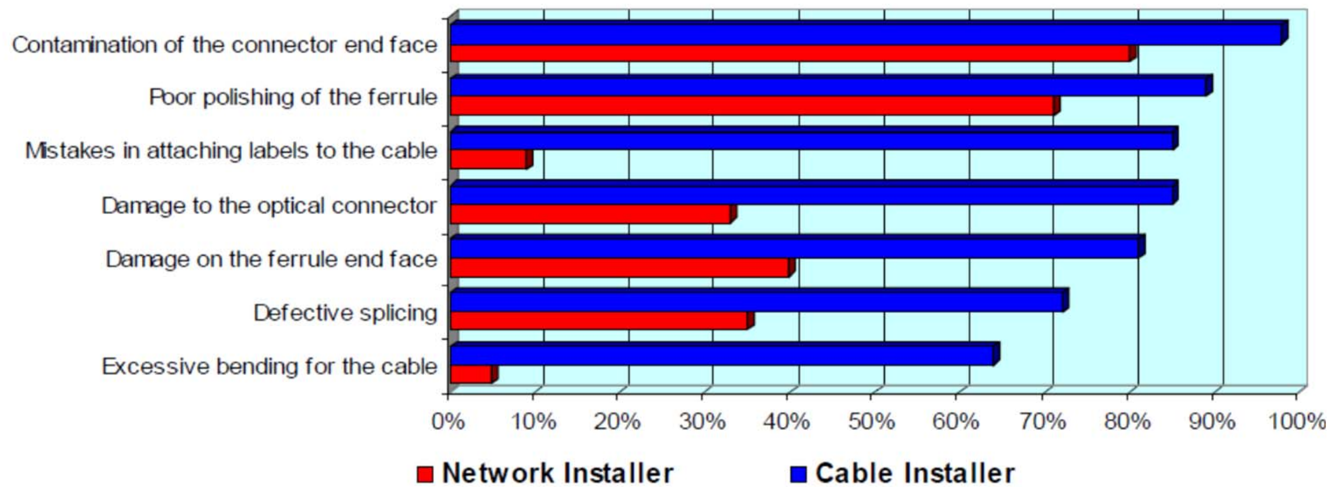
Presentation Outline

- Fiber optic connector inspection – why?
- Effects of Connector Contamination
- Standards for auto-analysis of endfaces
- Cleaning/Inspection Best Practices
- Multi-fiber/MPO Considerations
- Inspection image processing challenges
- New connectors for new applications

#1 Problem: Dirty / Damaged Connectors

- “98% of installers and 80% of network owners reported that issues with connector contamination were the greatest cause of network failure” – NTT Advanced Technology

Causes of Network Failures



Fiber Optic Connector Inspection – Why? (1 of 4)

Optical network operational realities are harsh

- Contaminated or damaged optical connectors can bring down networks
- PAM4 modulation for 100G single lambda transport has reduced optical link budgets, making sensitivity to connector attenuation and reflection increasingly pronounced – "You may have gotten away with it until now"
- Today's network operators must engage in 100% connector endface inspection to avoid costly network downtime

Fiber Optic Connector Inspection – Why? (2 of 4)

Evolution from single fiber cabling to multi-fiber cabling

- Appetite for ever higher broadband speeds
  - Multi-wavelength multiplexing per fiber
  - Higher frequency (lower wavelength) carriers
  - Parallel optics using multiple lanes of light

- Parallel Optics has driven the popularity of multi-fiber connectors, primarily MPO/MTP® variants
  - The worldwide installed base of MPO type connectors is more than 20M endpoints, with more than 4M endpoints to be commissioned in 2019 (conservative estimate)

Fiber Optic Connector Inspection – Why? (3 of 4)

- **The business need for fast optical connector inspection**
- The revenue asset value of a 400G link is about $1M per year
  - 400 customers at 1 Gbps at approximately $100 per month or so with 2:1 oversubscription)

- As many as 80% of network failures are related to connector failures
  - often migrating dirt and other debris driven by aggressive forced air cooling systems

- The average cost of a Data Center outage is about $740K *(Ponemon Institute / Emerson Network Power, Aug 2016)*

Fiber Optic Connector Inspection – Why? (4 of 4)

Workforce changes, OPEX reduction, and the need for simple test instruments

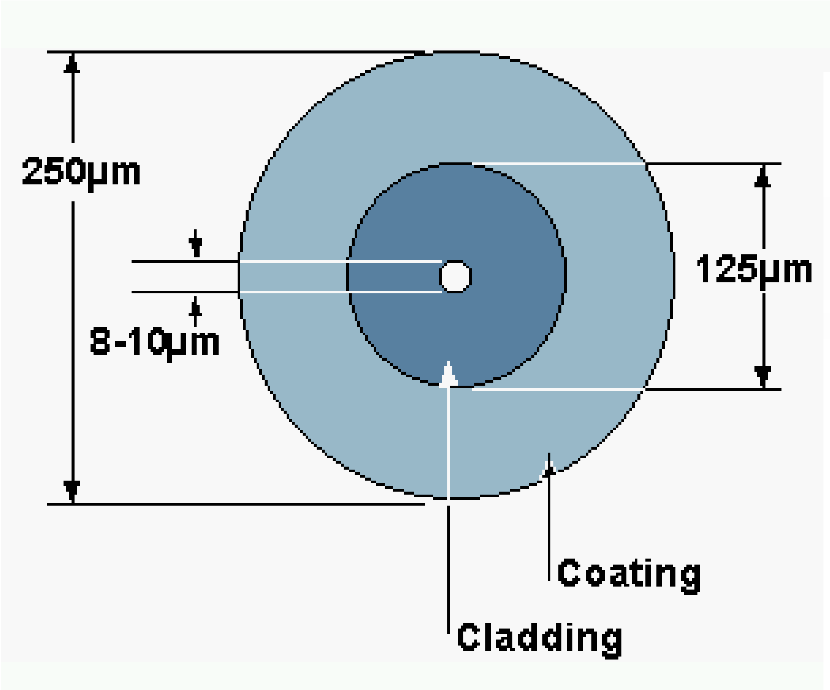
- Increasingly, network turn-up and maintenance tasks are outsourced to inexperienced technicians, many with limited fiber handling skills
- Corporate senior managers demand their teams constantly find ways to reduce operating expense
- Drives requirement that network test and inspection tools are simple to learn and use with easy reporting of results
  - A prevailing attitude in the *gig economy* - “trust but verify”

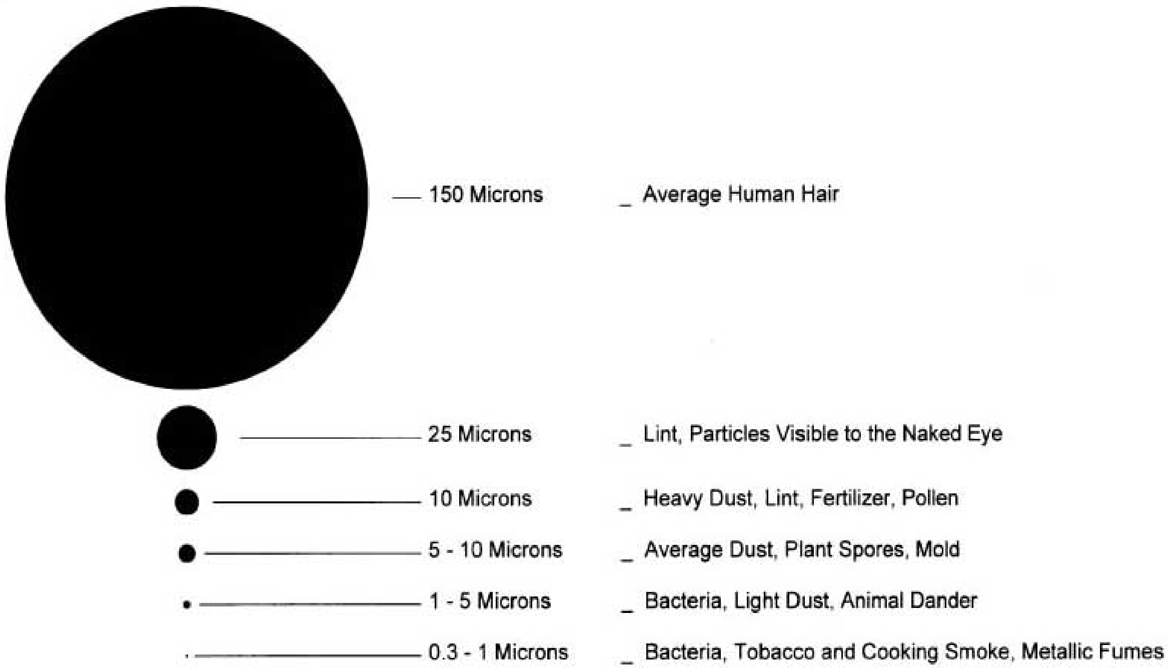
Fast endface inspection tools are essential to help address these rising cost trends

What Really Happens?

- Dust and dirt can literally block the light
- Dirt and oils can cause light to refract and be lost at the connection
- Particles can prevent proper mating of connectors
- Dirt can damage connector end face when mating and cause permanent damage – cleaning will no longer help

Contaminants and the Connector

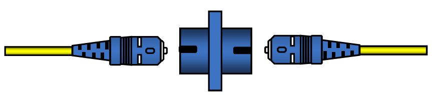


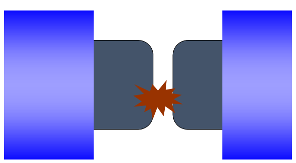


Importance of Cleaning & Inspection

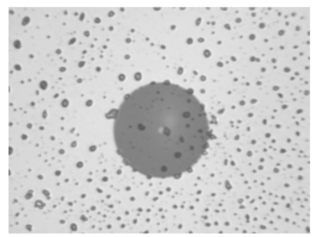
Dust/dirt residue transfer

- A connection is made of 2 connectors….
- They should both be inspected and cleaned if needs be.

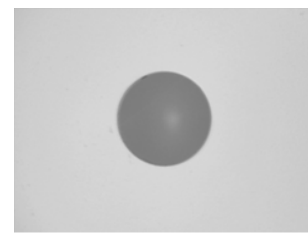




Before mating:

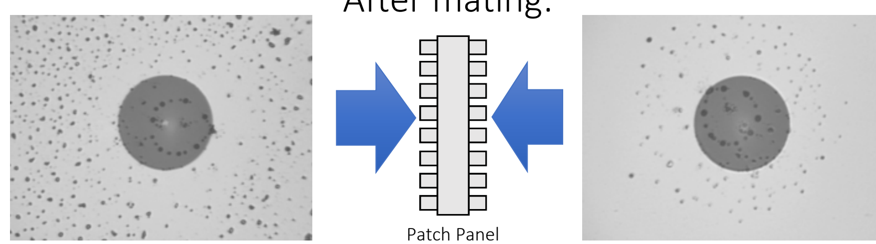


Connector A



Connector B

After mating:



What is Clean?

- IEC Standard Definition IEC 61300-3-35:2015

Table 4 – Visual requirements for multi-mode PC polished connectors

Zone[a]	Scratches (maximum number of a given dimension)	Defects (maximum number of a given dimension)
A: core 0 µm to 65 µm	No limit ≤ 3 µm None > 3 µm	4 ≤ 5 µm None > 5 µm
B: cladding 65 µm to 115 µm	No limit ≤ 5 µm None > 5 µm	No limit < 5µm 5 from 5 µm to 10 µm None > 10 µm
C: adhesive 115 µm to 135 µm	No limit	No limit
D: contact 135 µm to 250 µm	No limit	No limit < 20 µm 5 from 20 µm to 30 µm None > 30 µm

NOTE 1 There are no requirements for the area outside the contact. Cleaning loose debris beyond this region is recommended good practice. This is of particular concern for multiple-fibre rectangular-ferrule connectors.

NOTE 2 For multiple-fibre rectangular-ferrule connectors, the criteria apply to all fibres in the array.

NOTE 3 The zone size for multi-mode fibres has been set at 65 µm to accommodate both 50 µm and 62,5 µm core size fibres. This is done to simplify the grading process.

[a] For multiple-fibre rectangular-ferrule connectors only, the requirements of Zone A and Zone B apply.

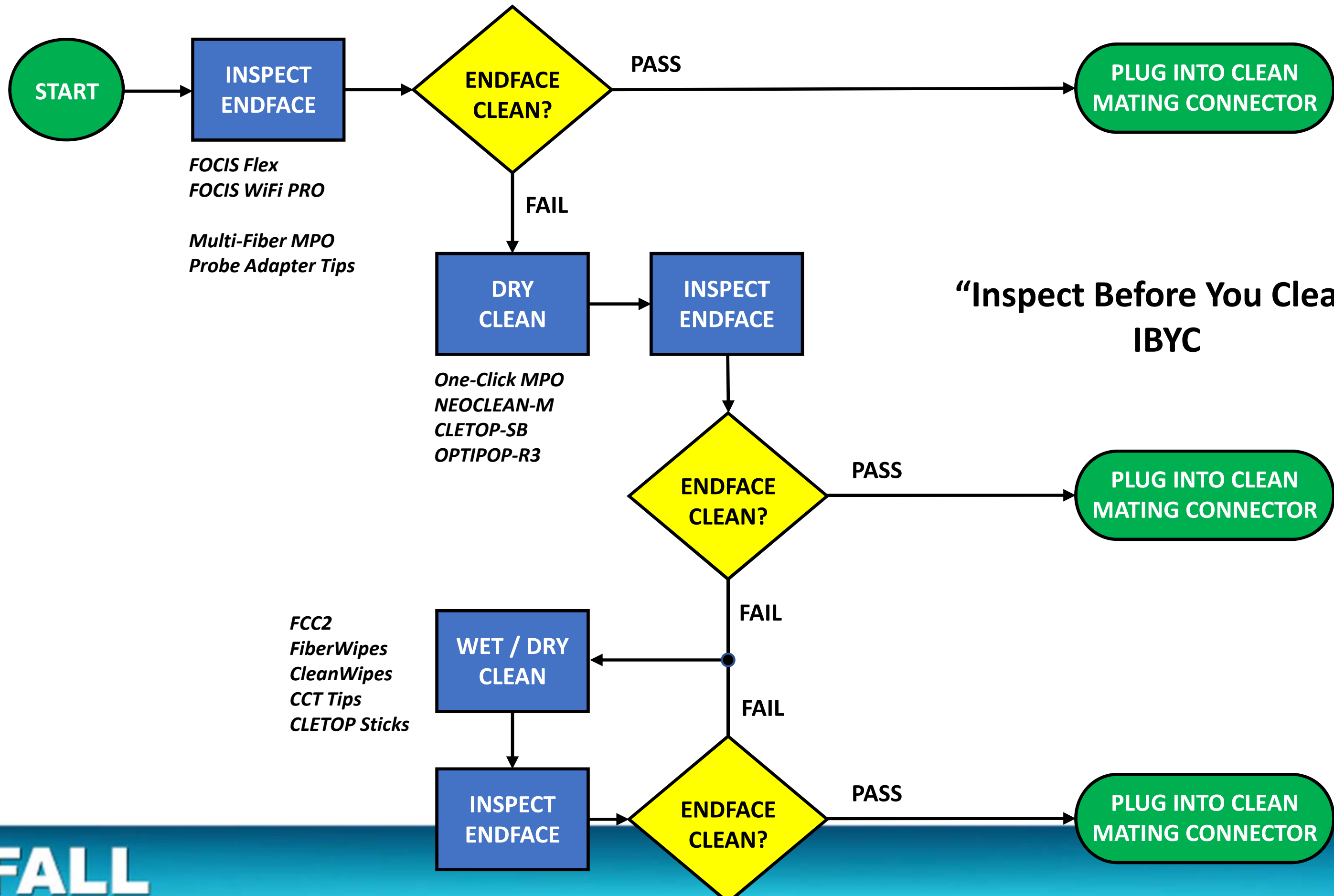
Standards for Auto-Analysis of Endfaces

International standards for auto-analysis

- IEC 61300-3-35 (2015) is the most commonly used international standard for pass/fail auto-analysis
- Defines two zones (core and cladding) to analyze for scratches and debris
- Pass/fail thresholds for both scratches/defects are established by count and by size
- This international standard is currently in the process of Edition 3 revision; a new revision is expected later this year or early 2020, with MPO/MTP inspection optimizations

IEC 61300-3-35

Cleaning & Inspection Best Practice



"Inspect Before You Clean"
IBYC

Step 1 - Inspect…

- You need to inspect **all** end faces in the connector
  - Inspect the entire connector to determine need for cleaning
  - Inspecting first verifies pre-connectorized products have been supplied in good condition
  - Just because a connector comes from the factory with a protective cap does not ensure it is clean

Step 2 - Clean…

- You need to be able to clean **all** of the end faces quickly and efficiently
  - There are cleaners available today specifically designed for multi-fiber connectors
  - Dry cleaning is quite effective, but is not perfect

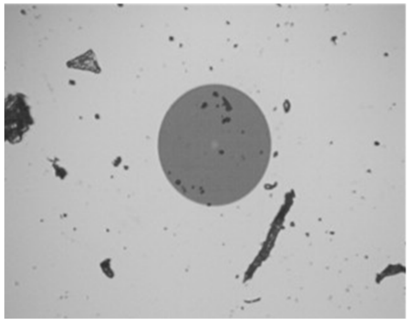
Step 3 – Inspect (again)

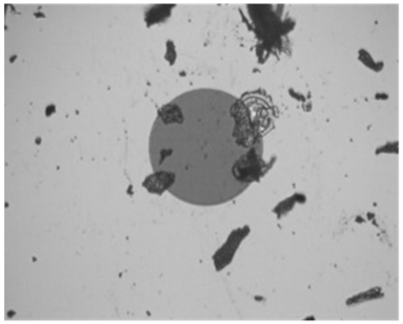
- After cleaning you need to inspect **all** end faces in the connector again
  - If not clean… repeat the process and inspect again
  - Many customers now require proof of inspection to certify installations
  - Saves time and money in the long run

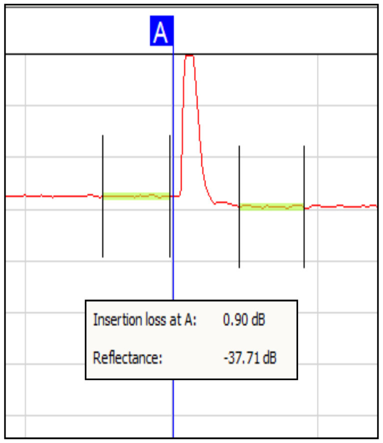
  - Once Cleaned and verified – safe to connect

Clean connectors matter!

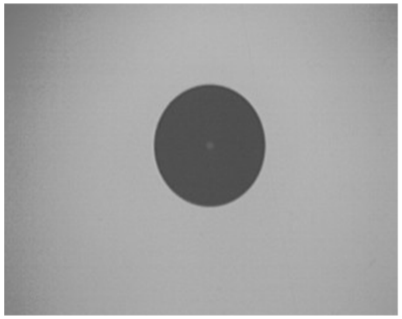
Dirty connectors = high insertion loss and high reflectance

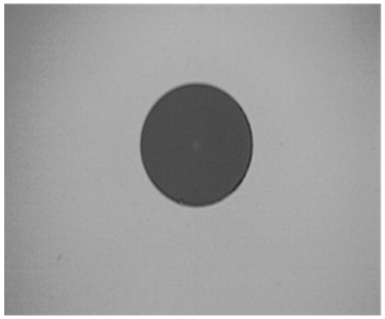


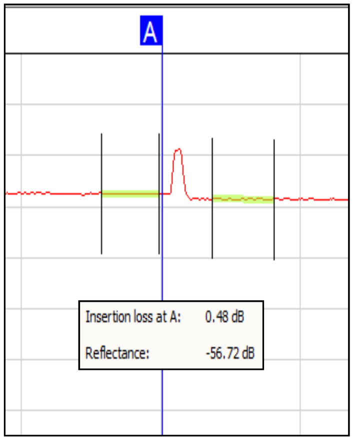




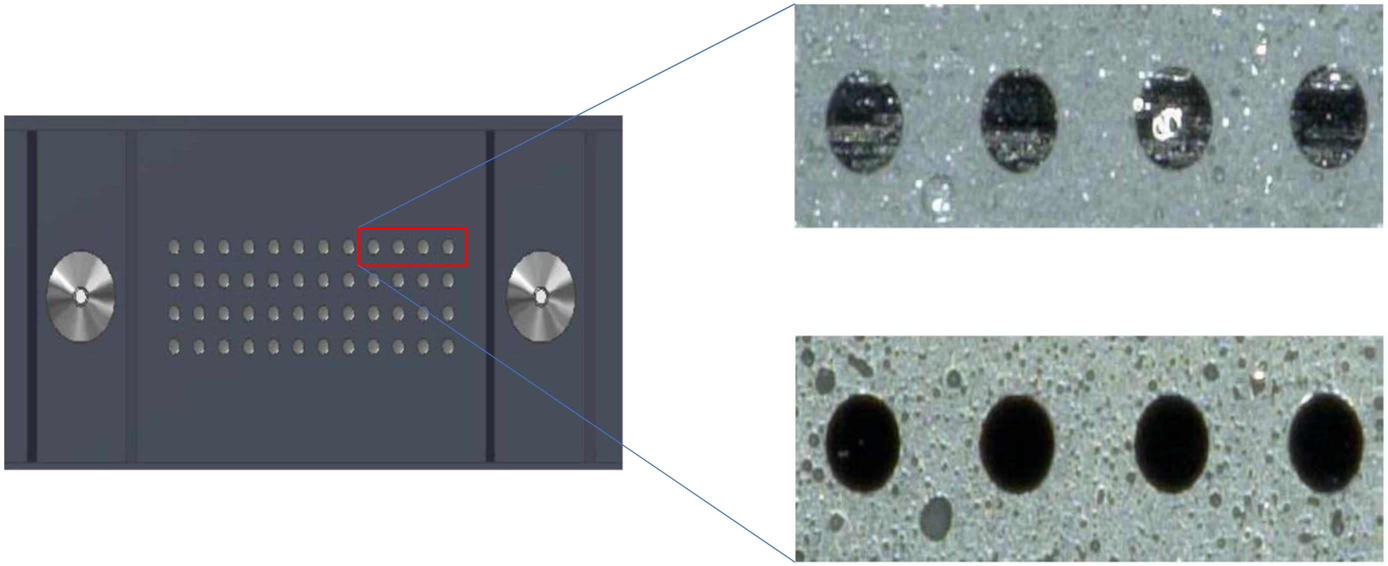
Clean connectors = low insertion loss and low reflectance







Multi-Fiber Connectors - MPO



- The problem is multiplied
- More fibers in same space

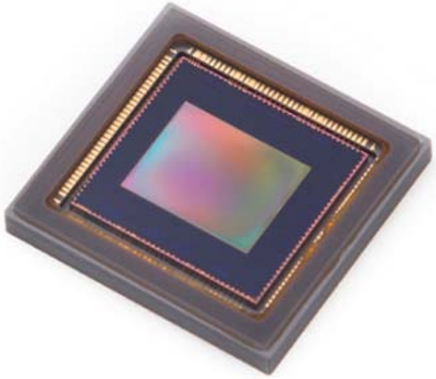
Inspecting Multi-Fiber Connectors

- For multi-fiber connectors the criteria applies to all fibers in the array.

- It is especially important to clean loose contaminants beyond the contact point (Holes/Pins)
  - Debris can migrate and the close spacing of the fibers increases the chances of contamination causing issues

Algorithmic Auto-Analysis of Endfaces

Algorithmic auto-analysis in fiber optic connector inspection workflows



- Handheld wireless microscopes use real-time image processing to automatically analyze endface surface conditions
- Today's inspection probes leverage the semiconductor sensors, microprocessors and memories found in modern smartphones
- Current generation fast MPO inspection probes can evaluate IEC pass/fail for each fiber in about 1 second (12 fiber MPO in about 10 seconds)
- This represents a true breakthrough as compared to older manual mechanical scanning methods (typically take about 60 seconds per fiber to position and run pass/fail analysis)

Inspection Image Processing Challenges

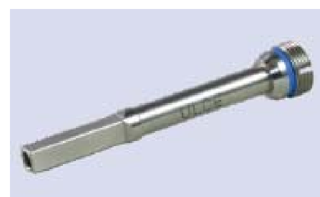
- Large number of variables to achieve consistent or repeatable auto-analysis connector inspection results
- MPO/MTP endface surface textures and colors vary widely from connector vendor to connector vendor
- Depending on the polish of the connector (flat UPC or 8 degree angled APC), the LED illumination level on the endface can vary dramatically
- Alignment sleeves (sometimes called bulkhead adapters) are precision manufactured but have tolerance limits
- Adapter tips used on the probes also have mechanical tolerance limits, which stack up with the alignment sleeve and the connector-under-test (patch cord or bulkhead) tolerances
- These physical realities limit the precision to which a real-time and low-cost microscope can make consistent and repeatable pass/fail judgments

New Connectors for New Applications

- Relentless demand for higher bandwidth drives to maximize switch faceplate density – typically limited by power and thermal management, and optical connector form factor issues

- Serial optics based 100G transceiver MSAs utilized duplex LC connectors – <u>but 6.25 mm ferrule pitch does not meet next generation Ethernet switch needs</u>

Typical Connector Cleaner



LC APC & UPC Bulkhead Adapter Tips

APC and UPC 1.25mm Adapter Tips

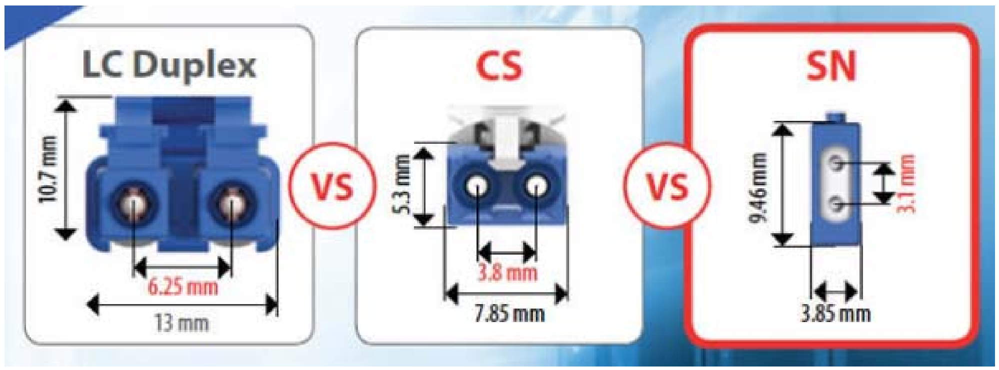
Patch Cord

Typical Single Fiber Inspection Scope

3.1 mm Ferrule Pitch Duplex Connectors

- Senko and US Conec have introduced new 1.25 mm ferrule duplex (and quadraplex, octaplex) connectors with tighter mechanical dimensions – **3.1 mm ferrule pitch**

SENKO Advanced Components



Eight 1.25 mm ferrules fit in one QSFP-DD transceiver faceplate = duplex 4x 100G single λ = 400G

USCONEC
MDC Connector

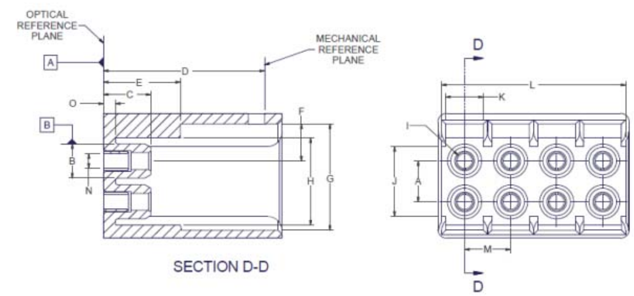


Figure 3.2 – MDC Receptacle Interface (QSFP-DD)

Next Gen Connector Support

Mechanical Push Type Connector Cleaner
For CS, SN, MDC Patch Cord endface cleaning

Typical
Wireless
Single Fiber
Inspection
Scope

Typical
Wireless
Multi-Fiber
Inspection
Scope

APC and UPC
1.25mm Adapter Tips
For CS, SN, and MDC
Patch Cords

Wrap Up

- Data is the life blood of our modern world
- Connected by a vast infrastructure – wired and wireless – to enable transitional and monumental opportunities
- The Modern Data Centers stands at the heart of this emerging reality….

The Data Singularity

Today's Modern Data Center

- High Density Optical Cable stands as the foundation to today's drive for more data
- Success requires interconnect management solutions that bring Order to Chaos
- Achieving low-loss interconnection is critical to meet the data rates required