Fiber Optic 101 and Cable Selection

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Title Sr. Sales Engineer
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Agenda

What Are We Going To Learn Today?

- Overview of Corning Cable Systems
  - Fiber Optic Technology 101
    - What is it?
    - How does it work?
    - Fiber Types
    - Fiber Performance
    - Benefits
  - Fiber Optic Cable 101
    - What is it?
    - Cable Construction
    - How to Pick a Fiber Optic Cable
    - Pulling Best Practices
- Fiber Optic Termination Methods
- Installing a Fiber Optic System
  - Components of an installation
- Review of Corning Cable Systems Offerings
Overview of Corning Cable Systems
Enterprise Networks: Solutions for Your Application
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Fiber Optics 101
What Is Fiber Optics?

General Definition
Transmitting information in the form of light, through a transparent medium, typically high-purity glass

Medium
Any material through which energy moves, over a distance

Examples:
- Sound through water
- Radio Signals through air
- Light through high-purity glass
Fiber Optics 101

What Is Fiber Optics?

Light Transmitting Through Glass

Fiber Optics 101
Properties of Electromagnetic Signals

Wavelength

The distance between identical points on a wave (typically expressed in nanometers or “nm”)

“B” represents a shorter wavelength than “A”
Fiber Optics 101
Electromagnetic Spectrum

Wavelength

UV Spectrum  Visible Spectrum  Infrared Spectrum

Operating Wavelengths:
• 850 nm = Short Wave Multimode
• 1300 nm = Long-Wave Multimode
• 1310 nm = Traditional Standard Single-mode
• 1490 nm = FTTx (Downstream Data/Voice)
• 1550 nm = Long-Wave Single-mode
• 1625 nm = Extra Long-Wave Single-mode (WDM)
Fiber Optics 101
Measuring Fiber Optics

- A micrometer, or **micron** (μm), is a metric measurement used to measure the diameter of a fiber.
  - One micron = 1 x 10^{-6} meters, one millionth of a meter.
  - One micron = 0.000039 inches
  - One human hair is ~ 80 microns

- A coated optical fiber is about 250 μm in diameter
- The light carrying region of an optical fiber can be as small as 10 μm or less.
- In optical fiber, some specifications are as tight as 0.5 μm!
Fiber Optics 101
Relative size of optical fiber

Optical fiber (glass only)  Fiberglass from ceiling tile  Human hair

500 μm
Fiber Optics 101
Principles of Operation — Theory

Cross section of a typical fiber

- **Core**
  - Carries the light signals

- **Cladding**
  - Keeps the light in the core
  - Can not be separated from the Core

- **Coating**
  - Protects the glass
  - Acrylate (plastic)
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  – Components of an installation

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Fiber Optics 101
How Does It Work?

Couple the light into the fiber and keep it there:
“Total Internal Reflection”
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    ➢ Benefits

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Fiber Optics 101
Fiber Performance is Measured in Bandwidth

**Bandwidth**

The capacity of a medium to carry information over a distance without loss of data

*(How much data can I carry and how far?)*

- Affected by
  - Source/Transmitter (the LASER, VCSEL, or LED)
    - Nominal wavelength, Spectral Width, Time Delays
  - Waveguide (the fiber)
    - Attenuation*
    - Dispersion*

*Both are affected by distance traveled*
Fiber Optics 101
Optical Sources

• Types
  – LED
    • Light Emitting Diode
    • Low cost (850nm, 1300nm)
  – LASER
    • Light Amplification from the Stimulated Emission of Radiation
    • High cost (1310nm, 1550 nm, 1625nm)
  – VCSEL
    • Vertical Cavity Surface Emitting Laser
    • Lower cost laser (850nm)

• Characteristics
  – Time Delay - Lag time of source to power up and power down
  – Spectral Width
Fiber Optics 101
Waveguide (*the* Fiber) Effects

- **Attenuation** – *loss* of signal strength
  - Expressed in decibels of power lost (dB)
  - Intrinsic Attenuation
  - Extrinsic Attenuation
  - Impacts ability to reach the receiver with sufficient power
  - A 3dB loss in power equates to a 50% loss from what you started with

- **Dispersion** – *spreading* of signal pulses
  - Modal Dispersion
  - Chromatic Dispersion
  - Impacts the ability to distinguish discreet signal pulses
Fiber Optics 101
Impact of dB Loss

For every 3dB loss of optical power, you lose 50% of what you had before...the "divorce law"
Fiber Optics 101
Intrinsic Attenuation

**Intrinsic Attenuation**

Loss of signal energy due to interaction between the photons and inherent physical properties of the fiber

*(Internal - Can’t be affected by outside influences)*

- **Absorption**
  - Photons give up kinetic energy to subatomic particles

- **Scattering**
  - Photons bounce off subatomic particles
Fiber Optics 101
Extrinsic Attenuation

**Extrinsic Attenuation**

Loss of signal energy due to change in dimensional properties of the fiber

*(External - Caused by outside influences)*

- Macrobends
- Microbends
- Imperfect Junctions
  - Splices
  - Fiber endfaces
Fiber Optics 101
Extrinsic Attenuation

**Macrobend**
Large-scale bend of the waveguide, which changes the angle of incidence of previously reflecting modes
(Generally across entire cross-section of the fiber)
Fiber Optics 101

Extrinsic Attenuation

**Microbend**

Small-scale distortion of the waveguide, which changes the angle of incidence of previously reflecting modes

(Might affect only one side of the core)
Dispersion

Spreading of signal pulses as they travel down the fiber
(May cause pulses to overlap as they arrive at the receiver, and cause bit errors)
Fiber Optics 101
Dispersion – Bit Error

Theoretical Input

Actual Input

Acceptable Pulse Broadening

Too Much Pulse Broadening
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Fiber Optics 101
Basic Types of Fiber

Mode

A single stream of photons that travels in a straight line unless acted upon by the environment

*A ray of light*

- **Single-mode (SM)**
  - Narrow Core (~8.3 µm)
  - Supports only one ray / mode

- **Multimode (MM)**
  - Broader Core (50-62.5 µm)
  - Supports many rays / modes

*Note: More Modes ≠ More Bandwidth*
Fiber Optics 101
Basic Types of Fiber

**Multimode Fibers**
- OM1
  - Core: ~62.5 µm
  - Cladding: ~125 µm
  - Coating: ~250 µm
- OM2, OM3, OM4
  - Core: ~50 µm
  - Cladding: ~125 µm
  - Coating: ~250 µm

**Single-mode Fiber**
- OS2
  - Core: ~8 µm
  - Cladding: ~125 µm
  - Coating: ~250 µm

---

- **Carries Signal**
- **Keeps Light in Core**
- **Protects The Glass**

Information Carrying Capacity
Fiber Optics 101
Basic Types of Fiber

Multimode Fiber
- 62.5 µm
- 50 µm

Single-mode Fiber
- ~9 µm
## Fiber Optics 101
Comparing Single-mode and Multimode Fibers

<table>
<thead>
<tr>
<th>Single-mode</th>
<th>Multimode</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Core Size (8.3 µm)</td>
<td>• Core Size (62.5 or 50 µm)</td>
</tr>
<tr>
<td>• Sources</td>
<td>• Sources</td>
</tr>
<tr>
<td>– Lasers</td>
<td>– LED or VCSEL</td>
</tr>
<tr>
<td>• 1310, 1550, 1625nm</td>
<td>• 850 or 1300nm</td>
</tr>
<tr>
<td>• Attenuation (typical)</td>
<td>• Attenuation (typical)</td>
</tr>
<tr>
<td>– 0.35/0.25 dB/km (1310/1550)</td>
<td>– 3.5/1.5 dB/km (850/1300)</td>
</tr>
<tr>
<td>• Dispersion</td>
<td>• Dispersion</td>
</tr>
<tr>
<td>– No Modal Dispersion</td>
<td>– Dominated by Modal Disp.</td>
</tr>
<tr>
<td>– <strong>Bandwidth:</strong></td>
<td>– <strong>Bandwidth:</strong> Limited</td>
</tr>
<tr>
<td>• Limited by electronics only</td>
<td>• Distance</td>
</tr>
<tr>
<td></td>
<td>• Fiber Type</td>
</tr>
<tr>
<td></td>
<td>• Source Type</td>
</tr>
</tbody>
</table>
Fiber Optics 101
Types of Single-mode and Multimode Fibers

**Single-mode**
- OS2 – SMF28e®
- NZ-DSF – LEAF
- Corning® ClearCurve®
  - 5 mm bend radius
  - Compatible with current SM fibers, equipment, & procedures

**Multimode**
- OM1 – LANscape® 62.5µm
- OM2 – LANscape® Pretium 150 (50µm)
- OM3 – LANscape® Pretium 300 (50µm)
- OM4 – LANscape® Pretium 550 (50µm)
- Corning® ClearCurve®
  - Industry leading macrobending performance below 10 mm radius
  - Available in OM2, OM3, & OM4
Fiber Optics 101
Comparing Multimode Fibers

Only evident physical difference is core size:
- 50 µm has greater bandwidth due to smaller core
- 50 µm has fewer modes → less modal dispersion
Fiber Optics 101
Comparing Multimode Fibers

50 µm
• Greater bandwidth
• Extended GigE and Fiber Channel range
• Accepted by TIA/EIA-568C
• We see more 50 µm in data centers
• Industry moving toward 50-micron fiber for bandwidth

62.5 µm
• Lower bandwidth
• Decreased range at 850nm
• Accepted by TIA/EIA-568C
• Greater installed base
• Previously the only MM fiber accepted by TIA/EIA-568C

Note: MM fiber types should not be mixed within the same LAN
Fiber Optics 101
Choosing Single-mode vs. Multimode Fibers

**Single-mode**
- **Applications:**
  - Backbones, longhaul, FTTx
- **Advantages:**
  - Longer lengths
  - Higher data rate systems
    - Video, gaming
  - Lower attenuation
  - Lower dispersion
- **Disadvantages:**
  - More expensive sources
  - More difficult to align cores

**Multimode**
- **Applications:**
  - DataCenters, LAN
- **Advantages:**
  - Easier core alignment
  - Less expensive sources
  - Less expensive connectors / adapters
- **Disadvantages**
  - Shorter lengths
  - Lower data rate systems
  - Modal Dispersion
  - Higher attenuation
Fiber Optics 101
Why Fiber? - Longer Distances *

* Typical distance for 1 Gbps system capability
Fiber Optics 101

Distances * (without single-mode)

* Typical distance for 1 Gbps system capability
# Fiber Optics 101
## SM and MM Fiber Distance Capabilities

## TRANSMISSION PERFORMANCE

<table>
<thead>
<tr>
<th></th>
<th>OM1</th>
<th>OM3</th>
<th>OM4</th>
<th>OS2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optical Fiber Type</strong></td>
<td>62.5 µm Multimode</td>
<td>50 µm Multimode</td>
<td>50 µm Multimode</td>
<td>Single-Mode</td>
</tr>
<tr>
<td><strong>Wavelength</strong></td>
<td>850 nm/1300 nm</td>
<td>850 nm/1300 nm</td>
<td>850 nm/1300 nm</td>
<td>1310 nm/1550 nm</td>
</tr>
<tr>
<td><strong>Maximum Loose Tube Attenuation</strong></td>
<td>3.4/1.0 dB/km</td>
<td>3.0/1.0 dB/km</td>
<td>3.0/1.0 dB/km</td>
<td>0.4/0.3 dB/km</td>
</tr>
<tr>
<td><strong>Maximum Tight-Buffered Cabled Attenuation</strong></td>
<td>2.8/1.0 dB/km</td>
<td>2.8/1.0 dB/km*</td>
<td>2.8/1.0 dB/km*</td>
<td>0.65/0.5 km</td>
</tr>
<tr>
<td><strong>Minimum Over Filled Launch (OFL) Bandwidth</strong></td>
<td>200/500 MHz•km</td>
<td>1500/500 MHz•km</td>
<td>3500/500 MHz•km</td>
<td>– / –</td>
</tr>
<tr>
<td><strong>Minimum Effective Modal Bandwidth (EMB)</strong></td>
<td>2200/– MHz•km</td>
<td>2000/– MHz•km</td>
<td>4700/– MHz•km</td>
<td>– / –</td>
</tr>
<tr>
<td><strong>Serial 1 Gigabit Ethernet Distance</strong></td>
<td>300 m/550 m</td>
<td>1000 m/600 m</td>
<td>1000 m/600 m</td>
<td>5000 m/ –</td>
</tr>
<tr>
<td><strong>Serial 10 Gigabit Ethernet Distance</strong></td>
<td>33 m/-</td>
<td>300 m/-</td>
<td>550 m/- **</td>
<td>10000 m/40000 m</td>
</tr>
</tbody>
</table>

*TRFEDM® LST™ cable attenuation is 3.0/1.0.

**IEEE 802.3 specifies a maximum distance of 400 meters for 10GBASE-SR transmission. 550 meters is considered an acceptable engineered-length distance utilizing a complete Corning solution.

Contact Corning Customer Care at 800-743-2675 for information.
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- Fiber Optic Termination Methods
- Installing a Fiber Optic System
  - Components of an installation
- Review of Corning Cable Systems Product Offerings
# Fiber Optics 101

## Benefits of Optical Fiber

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
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<tbody>
<tr>
<td>Low insertion loss</td>
<td>Longer distances</td>
</tr>
<tr>
<td>High bandwidth</td>
<td>Greater information capacity</td>
</tr>
<tr>
<td>Immune to EMI &amp; RFI</td>
<td>No crosstalk</td>
</tr>
<tr>
<td>Difficult to tap</td>
<td>Secure</td>
</tr>
</tbody>
</table>
Fiber Optics 101
Benefits of Optical Fiber

**Features**
- Dielectric construction
- Light weight/small size
- Application-independent

**Benefits**
- Eliminates grounding considerations/shock hazards
- Longer pulls possible
  Minimal space used
- Supports data, voice, video, process control, etc.
Fiber Optics 101
Intrinsic Strength…the Facts!

• Measured fiber intrinsic strength compared to other materials
Fiber Optics 101

Fiber versus Copper

- A fiber optic cable with the **same bandwidth capacity** as a comparable copper cable is less than **1% of both the size and weight**
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    ➢ Cable Construction
    ➢ How to Pick a Fiber Optic Cable
    ➢ Pulling Best Practices
• Fiber Optic Termination Methods
• Installing a Fiber Optic System
  – Components of an installation
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Fiber Optic Cable 101

What is Fiber Optic Cable?

**General Definition:**
Fibers packaged and bundled together for maximum mechanical and physical protection.

**Standard Types:**
- Indoor Tight Buffered Cables
- Outdoor Cables
- Indoor/Outdoor Cables
  - Tight Buffered
  - Loose Tube
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➢ Fiber Optic Cable 101
  ➢ What is it?
  ➢ **Cable Construction**
    ➢ How to Pick a Fiber Optic Cable
    ➢ Pulling Best Practices

• Fiber Optic Termination Methods
• Installing a Fiber Optic System
  – Components of an installation
• Review of Corning Cable Systems Offerings
Fiber Optic Cable 101
Fiber Coloring

• Purpose
  – Provides fiber identification
• Coloring ink applied directly on the coated fiber.
• Standard US Color Code
  – Blue, orange, green, brown, slate, white, red, black, yellow, violet, rose, aqua
Fiber Optic Cable 101
Cable Jacket Identification

- **Purpose**
  - Provides fiber type identification (Indoor Cables)
  - Provides UV protection (Outdoor Cables)

- Orange = OM1 and OM2
- Aqua = OM3 and OM4
- Yellow = OS2 (SM)
- Black = Outdoor Cables
Fiber Optic Cable 101
Indoor Tight Buffered Cable

- Primarily used indoors (exception: FREEDM® One)
  - Building and data center backbones
  - Horizontal applications
  - Patch cords and equipment cables
- Meet applicable flame listing requirements
- Increased flexibility
- Easy to field-terminate
- Variety of fiber counts and cable designs
Fiber Optic Cable 101
Tight-Buffered Fiber Construction

• Buffer material applied directly to the 250 µm fiber to obtain a 900 µm outer diameter
• To construct cable, 900 µm may be
  – Stranded or unitized
• Lacks environmental and mechanical robustness of Loose Tube cable
Fiber Optic Cable 101
Tight-Buffered Fiber Construction

- TBII® Buffered Fiber uses a patented process that allows for easy removal of the buffering material for splicing or connectorization.
Fiber Optic Cable 101
Indoor Tight-Buffered Cable Manufacturing

**Multifiber**
- Raw material (fiber)
- Fiber buffering
- Stranding/subunit jacketing
- Jacketing
- Quality control
- Shipping

**Single-Fiber**
- Raw material (fiber)
- Fiber buffering
- Jacketing
- Quality control
- Shipping
Fiber Optic Cable 101
Common Indoor Tight Buffered Cables

MIC® Cable

Legend
A - Flame-Retardant Outer Jacket
B - Ripcord
C - Dielectric Strength Members
D - Dielectric Strength Members
E - Tight-Buffered Fiber
F - Dielectric Strength Members

Unitized MIC® Cable

Legend
A - Ripcord
B - Flame-Retardant Outer Jacket
C - Dielectric Strength Members
D - Ripcord
E - Tight-Buffered Fiber
F - Dielectric Central Element
G - Flame-Retardant Subunit Jacket
Fiber Optic Cable 101
Common Indoor Tight Buffered Cables

MIC® Interlocking Cable

Legend
A - Flame-Retardant Outer Jacket
B - Interlocking Armor
C - Flame-Retardant Inner Jacket
D, E, & F - Dielectric Strength Members
G - Tight-Buffered Fiber
H - Ripcord

MIC® DX Armored Cable

Legend
A - Flame-Retardant Outer Jacket
B - Flame-Retardant Inner Jacket
C - Tight-Buffered Fiber
D, E, & F - Dielectric Strength Members
G - Dielectric Armor
Fiber Optic Cable 101
Tight Buffered Considerations – Flame Ratings

- National Electric Code (NEC)
- OFNP = Plenum
  - Highest rating – plenum air handling spaces
- OFNR = Riser
  - Middle rating – vertical cable runs
- OFN = General
  - Lowest rating – horizontal cable runs (non-plenum or riser)
- Outside Plant Cable is not flame rated and up to 50 feet can be inside a building
Fiber Optic Cable 101
Tight Buffered Considerations – Flame Ratings

NEC® Article 770

Nonconductive

Plenum
OFNP

Riser
OFNR

General Purpose
OFNG
OFN

Conductive

OFCP

OFCR

OFCG
OFC
Fiber Optic Cable 101
Tight Buffered Cable Applications

- MIC® Plenum Cable
- MIC® DX Armored Plenum Cable
- FREEDM® One Riser Cable
Fiber Optic Cable 101
Outdoor Loose Tube Cables

- Designed for harsh outdoor installations
- Tensile Strength Elements
  - Central member
    - Dielectric or Steel
    - Maintains bend radius
  - Aramid yarns provide tensile strength
- Cable Waterblocking Material
- Ripcord for accessing core
- Jacket
  - Polyethylene
  - Protection of cable core
  - Chemical resistance
  - UV and abrasion resistance
Stranded Loose Tube

Raw material (fiber)

Fiber coloring

Fiber buffering

Stranding

Jacketing

Quality control

Shipping
Fiber Optic Cable 101
Outdoor Loose Tube Cable Construction

- **Buffer Tube**
  - 250 µm fibers placed in buffer tube
- **Gel-free design is fully waterblocked using craft-friendly water-swellable materials**
  - Makes cable access simple and requiring no clean up
Fiber Optic Cable 101
Loose Tube Cable Fiber Buffering

Neutral State

Buffer Tube Contraction (Cold Weather)
Fiber Optic Cable 101
Loose Tube Cable Fiber Buffering

Buffer Tube Expansion

- Fiber Bundle
- Buffer Tube
- Central Member
Fiber Optic Cable 101
Outdoor Loose Tube Cable Stranding

- **Central member**
  - Tensile strength
  - Anti-buckling
  - Steel or dielectric

- **SZ stranding**
  - Tensile force reduction
  - Ease of tube access
    - Midspan access
  - Eliminates preferential bending

- Completed stranded unit
  sometimes called “**cable core**”

Switch-backs allow ease of single tube access
Fiber Optic Cable 101
Outdoor Loose Tube Cable Jacketing

• **Jacket**
  – Polyethylene
  – Protection of cable core
  – Chemical resistance
  – UV and abrasion resistance

• **Jacket over armor**
  – Same outer jacket protection
  – Armor
    • Corrugated steel tape
    • Provides rodent resistance
    • Provides mechanical protection
    • Used for toning cable
Fiber Optic Cable 101
Common Outdoor Loose Tube Cables

ALTOS® Dielectric Cable

ALTOS® Armored Cable

Legend
A - Ripcord
B - Dielectric Central Member
C - Buffer Tube
D - Dielectric Strength Members
E - Fiber
F - Polyethylene (PE) Outer Jacket

Legend
A - Ripcord
B - Dielectric Central Element
C - Fiber
D - Buffer Tube
E - Water-Swellable Tape
F - Corrugated Steel Armor
G - Polyethylene (PE) Outer Jacket
Fiber Optic Cable 101
Indoor/Outdoor Cables (Loose Tube & Tight Buffered)

- FREEDM® Cables
  - Plenum or Riser rated options
  - All dielectric or armored
  - Eliminates need for transition splice
  - Aerial, conduit, & direct buried if armored
- UV-resistant outer jacket
- Water-blocked cable and buffer tubes
- High tensile strength to protect fibers during installation
- Extreme temperature tolerance
Fiber Optic Cable 101
Common Indoor/Outdoor Loose Tube Cables

FREEDM® Loose Tube

FREEDM® LST

Legend
A - FR / UV-Resistant Outer Jacket
B - Ripcord
C - Dielectric Central Element
D - Fiber
E - Buffer Tube
F - Filling Element
G - Water-Swellable Tape

Legend
A - FR / UV-Resistant Outer Jacket
B - Ripcord
C - Fiber
D - Buffer Tube
E - Dielectric Strength Members
Fiber Optic Cable 101
Common Indoor/Outdoor Tight Buffered Cables

FREEDM® One Cable

Legend
A - Dielectric Strength Yarns
B - Ripcord
C - Dielectric Strength Yarns
D - Dielectric Strength Yarns
E - Tight-Buffered Fiber
F - FR / UV-Resistant Outer Jacket

FREEDM® One Interlocking Armor Cable

Legend
A - FR / UV-Resistant Outer Jacket
B - Ripcord
C - Dielectric Strength Yarns
D - Dielectric Strength Yarns
E - Dielectric Strength Yarns
F - Tight-Buffered Fiber
G - FR / UV-Resistant Inner Jacket
H - Interlocking Armor
Fiber Optic Cable 101
Indoor/Outdoor Colored Jackets

• **Which Indoor/Outdoor cables?**
  Industrial LSZH™, ALTOS LSZH, FREEDM® One, FREEDM LST™ and FREEDM Loose Tube (<\(= 72\)f) Cables.

• **What color options are available?**
  Any of the 12 standard colors defined by TIA/EIA-598, “Optical Fiber Cable Color Coding” are available: Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, Aqua.
Fiber Optic Cable 101

ALTOS® Cable with FastAccess™ Technology

- Co-extruded jacket feature allows easy jacket removal
- Gel-Free All Dielectric only
- Available with all standard fiber types
- Ripcord will be removed
- No stripes
- Special print statement
  - *ALTOS® Cable with FastAccess(TM) Technology*
- Meets OSP cable standards
  - Telcordia GR-20 and ICEA-640
  - Same specs, weights, and dimensions as standard ALTOS All-Dielectric Gel-Free cable
Fiber Optic Cable 101
ALTOS® Cable with FastAccess™ Technology

• Enterprise Networks will take to market at Fall BICSI
  – Week of Sept. 16, 2012
• Value Prop
  – Simple/quick cable access
  – Limits mistakes for inexperienced craft
  – No price increase
  – Differentiated cable product when combined with gel-free technology
  – Provides an advantage for 65% of:
    • Enterprise Market
    • Outside Plant Market
    • Loose Tube Market
Fiber Optic Cable 101

ALTOS® Cable with FastAccess™ Technology
Fiber Optic Cable 101
Loose Tube Cable Applications

ALTOS® All-Dielectric Cable

ALTOS® Armored Cable

Greater than 50 feet

FREEDM® Loose Tube Riser Cable

Duct Bank

ALTOS® All-Dielectric Cable
Agenda
What Are We Going To Learn Today?

• Overview of Corning Cable Systems
• Fiber Optics 101
  – What is it?
  – How does it work?
  – Fiber Types
  – Fiber Performance
  – Benefits over Copper
• Fiber Optic Cable 101
  – What is it?
  – Cable Construction
  – How to Pick a Fiber Optic Cable
  – Pulling Best Practices
• Fiber Optic Termination Methods
• Installing a Fiber Optic System
  – Components of an installation
• Review of Corning Cable Systems Offerings
Fiber Optic Cable 101
How to Pick a Fiber Optic Cable

• If Indoor….
  – Fiber Count
    • ≤ 24 Fibers = MIC® Cable
    • > 24 Fibers = MIC® Unitized Cable
  – Flame Rating
    • Riser or Plenum
  – Installation
  – Need for extra protection
    • Dielectric or Interlocking Armor
Fiber Optic Cable 101
How to Pick a Fiber Optic Cable

• Where and how will the cable be installed?
  – Outdoor, Indoor, or Both?
• If Outdoor…
  – Environment
  – Installation Technique
    • Direct Buried
    • Aerial
    • Duct
  – If armor is needed
Fiber Optic Cable 101
How to Pick a Fiber Optic Cable

• If Indoor/Outdoor….
  – Fiber Count
    • ≤ 24 Fibers = FREEDM® One Cable
    • > 24 Fibers = FREEDM® Loose Tube Cable
  – Flame Rating
    • Riser or Plenum
  – Installation
  – Need for extra protection
    • Interlocking Armor
  – Termination Method
    • Direct or Fan-Out
Fiber Optic Cable 101
Summary

- **Tight Buffered Cables**
  - Mainly used indoors
  - 900 um coated fiber
  - Meet applicable flame listing requirements
  - Common CCS brands are MIC® and FREEDM® One

- **Loose Tube Cables**
  - Mainly used outdoors
  - 250 um coated fiber
  - Operate in large temperature window
  - Common CCS brands are Altos® FREEDM® Loose Tube

- **Indoor/Outdoor Cables** such as FREEDM®
  Plenum can go anywhere
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➢ Fiber Optic Cable 101
  ➢ What is it?
  ➢ Cable Construction
  ➢ How to Pick a Fiber Optic Cable
  ➢ Pulling Best Practices

• Fiber Optic Termination Methods
• Installing a Fiber Optic System
  – Components of an installation
• Review of Corning Cable Systems Offerings
Numerous cable installation techniques exist and each can present a unique set of safety hazards. Take the utmost care to make sure you are aware of all hazards that may be encountered with any work activity. For specific safety requirements and practices, consult, at a minimum, your Company’s policies and procedures, federal, state, and local requirements/standards, and manufacturer* recommendations.

* “manufacturer” in this case, suggests manufacturers of installation equipment.
Fiber Optic Cable 101
Cable Placement Considerations

- Ensure sufficient slack
- Monitor tension
- Maintain minimum bend radius
- Protect exposed cable
Fiber Optic Cable 101
OSP Cable Pulling Best Practices

- Choose a Reputable Supplier
  - Conducts rigorous testing
  - Provides installation guidelines
- Inspect Your Reel
  - Conduct On-reel-testing to verify cable was correctly shipped
  - Check cable for signs of excessive weathering
- Choose Proper Installation Hardware
  - Choose fiber cable with proper tension and bend limits
  - Use the right tools for the task
- Control Cable Installation to Avoid Common Mistakes
  1: Paying off the cable
  2: Entering and exiting ducts
  3: Handling the cable at midspan points
  4: Jetting Cable Direct Burial

- Additional Information
  “Avoiding a Costly Crush”
Cable Stripping Hands-on
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Fiber Termination
Termination Methods

Epoxy and Polish
Anaerobic Connector Tool Kit

No Epoxy and No Polish
UniCam® High Performance Tool Kit

Fusion Splicing
Pigtail Splicing

Preterminated Cable
Plug & Play™ Solutions
Fiber Termination
Anatomy of a Fiber Optic Connector
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  ➢ Installing a Fiber Optic System
  ➢ Components of an installation
• Review of Corning Cable Systems Offerings
Installing a Fiber Optic System
Components of an Installation

• **Cable**
  - Fiber Type (MM = OM1, OM2, OM3, or SM = OS2)
  - Indoor, Outdoor, or Indoor/Outdoor Cable

• **Connectors**
  - Termination Method
    • Anearobic, Unicam, fusion splicing, or preterm
  - Connector Type
    • Fiber and Connector Compatibility

• **Hardware**
  - Wall Mount or Rack Mount
  - Connector and Fiber Type
  - Indoor or Outdoor Application
Installing a Fiber Optic System

Hardware Options

Rack Mount

- CCH

Wall Mount

- WCH

Outside Plant

- SCF Closures

Pre-terminated

- Preterm EDGE
Installing a Fiber Optic System

Example of a Fiber Optic System

- Electrical Data Converted to Pulses of Light
- Pules of Light Converted back to Electrical Data
- Fiber Optic Cabling (channel)
- Connection Point
- Connection
- Connection
- Patch Cord
- Patch Panel
- Link
- Patch Panel
- Patch Cord
- Transceiver
- Transceiver

Interconnect Patch Panel
Multimode Fiber 1.5 dB Total Connector Loss