

THE NEW OPTICAL FIBRE CATEGORIES

What do they promise?

prepared and delivered
by



FIA Breakfast Seminar
13th March 2001



The Cabling Partnership

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Training

Design and specification

Cabling/ IT cost management

Project management

Audits and arbitration

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Standards

UK

- Fibreoptic Industry Association, Technical Director
- BSI, Chairman, TCT7/-/1: IT Cabling

PD1001: "EMC and Structured Cabling"
BS 7718: CoP "Installation of Fibre Optic Cabling"

Europe

- CENELEC, Convenor, TC215 WG1: IT Cabling

EN 50098-1: "ISDN Basic Access"
EN 50098-2: "ISDN Primary Rate"
EN 50173: "Generic - Design"
EN 50174-1: "Installation: Specification & Quality Assurance"
EN 50346: "Testing of Installed Cabling"

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International

- ISO/IEC, Member, JTC1 SC25 WG3: Generic Cabling

ISO/IEC 11801: "Generic - Design"
ISO/IEC 14763-1: "Administration"
ISO/IEC TR14763-2: "Planning and Installation"
ISO/IEC TR14763-3: "Testing Optical Cabling"
and via IEC SC46A WG2
IEC 61935-1: "Testing Copper Cabling"

- ISO/IEC, Editor, JTC1 SC25 PT SOHO

ISO/IEC 15018: "SOHO - Design"

Agenda

Session One

**What are the new
OF Categories?**

Why do we need them?

What do they promise?

When can we have them?

Break

Session Two

**10Gbit Ethernet
“the grand plan”**

FIA LAN ASG

Future FIA publications

End

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MMF Specification - I

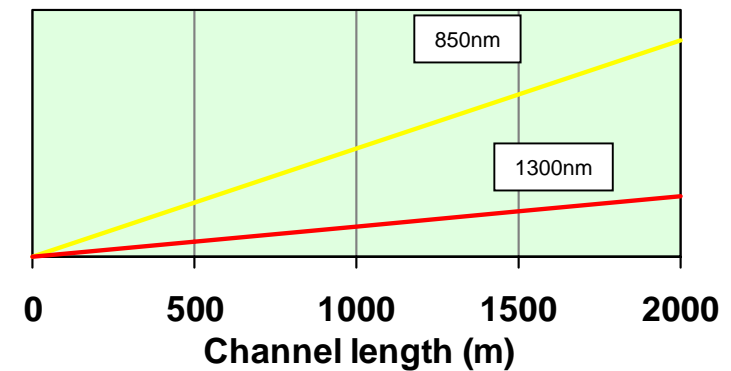
Optical fibre geometry (standardized)

| | 50/125 | 62.5/125 |
|-------------------------------------|------------------|-------------------|
| Core diameter (μm) | 50 ± 3 | 62.5 ± 3 |
| Cladding diameter (μm) | 125 ± 3 | 125 ± 3 |
| NA | 0.20 ± 0.015 | 0.275 ± 0.015 |

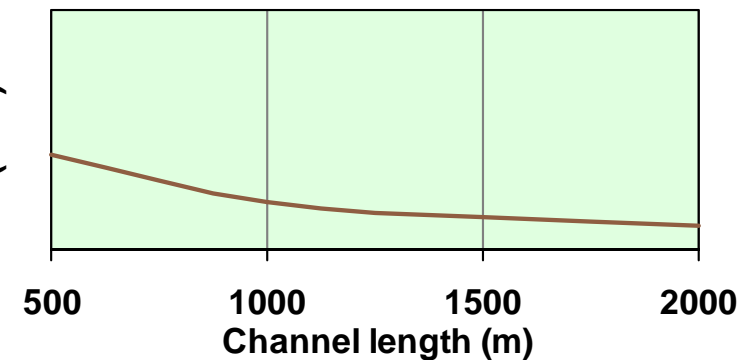
Optical fibre performance parameters (options)

| Attenuation coefficient dBkm^{-1} max. | | Modal bandwidth MHz.km min. | |
|---|--------|--------------------------------------|--------|
| 850nm | 1300nm | 850nm | 1300nm |
| ? | ? | ? | ? |

Attenuation (dB)



Modal Bandwidth (MHz)



MMF Specification - II

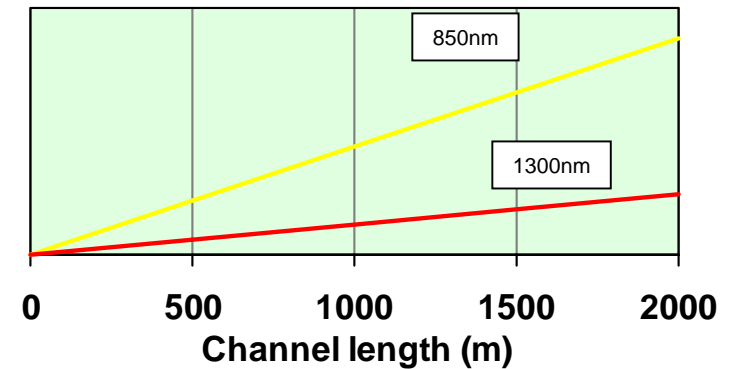
Optical fibre geometry (standardized)

| | 50/125 | 62.5/125 |
|-------------------------------------|------------------|-------------------|
| Core diameter (μm) | 50 ± 3 | 62.5 ± 3 |
| Cladding diameter (μm) | 125 ± 3 | 125 ± 3 |
| NA | 0.20 ± 0.015 | 0.275 ± 0.015 |

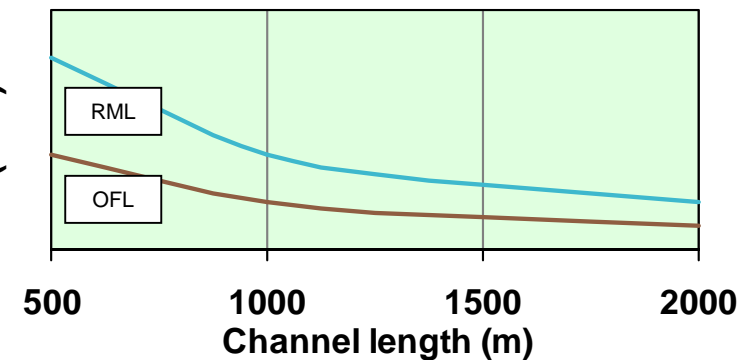
Optical fibre performance parameters (options)

| Attenuation coefficient dBkm^{-1} max. | | Modal bandwidth MHz.km min. | | Modal bandwidth MHz.km min. | |
|---|--------|-----------------------------|--------|-----------------------------------|-------------------------------------|
| 850nm | 1300nm | 850nm | 1300nm | 850nm | 1300nm |
| ? | ? | ? | ? | ? | ? |
| | | | | Overfilled launch LED-like | Restricted launch LASER-like |

Attenuation (dB)



Modal Bandwidth (MHz)



MMF Performance Options '95

| | Attenuation coefficient dBkm ⁻¹ max. | | Modal bandwidth MHz.km min. | | |
|---------------------|--|--------|--------------------------------|--------|-----------------------------------|
| | 850nm | 1300nm | 850nm | 1300nm | |
| 50/125 and 62.5/125 | 3.5 | 1.0 | 200 | 500 | ISO/IEC 11801 and EN 50173 (1995) |
| 62.5/125 | 3.75 | 1.5 | 160 | 500 | ANSI/TIA/EIA 568A (1995) |

| | Attenuation coefficient dBkm ⁻¹ max. | | Modal bandwidth MHz.km min. | | | | | |
|----------|--|--------|--------------------------------|--------|-------|------------------------|-----|------|
| | 850nm | 1300nm | 850nm | 1300nm | 850nm | 1300nm | | |
| 50/125 | 2.4 | 0.6 | 50/125 | 400 | 400 | 50/125 and 62.5/125 | | |
| | 2.5 | 0.8 | | 400 | 600 | | | |
| | 2.7 | 1.0 | | 400 | 800 | 62.5/125 | | |
| 62.5/125 | 3.0 | 0.7 | | 400 | 1000 | | | |
| | 3.2 | 0.9 | | 400 | 1200 | | 200 | 200 |
| | | | | 400 | 1500 | | 250 | 1000 |
| | | | 600 | 1000 | 300 | 800 | | |

MMF Categories - 2002

| | | 50/125 or 62.5/125 | | | |
|--|---------|--------------------|-----|------|-----|
| | | Multimode OF | | | |
| | | Wavelength | OM1 | OM2 | OM3 |
| Attenuation coefficient (dBkm ⁻¹ max) | 850 nm | 3,5 | | | |
| | 1300 nm | 1,5 | | | |
| Modal bandwidth OFL (MHz.km min) | 850 nm | 200 | 500 | 500 | |
| | 1300 nm | 500 | 500 | 500 | |
| Modal bandwidth RML (MHz.km min) | 850 nm | ffs | ffs | 2000 | |
| | 1300 nm | ffs | ffs | ffs | |
| Propagation delay (ns.m ⁻¹ max) | 850 nm | 5 | | | |
| | 1300 nm | | | | |

In reality OM1 is 62.5, OM2 and OM3 are 50/125

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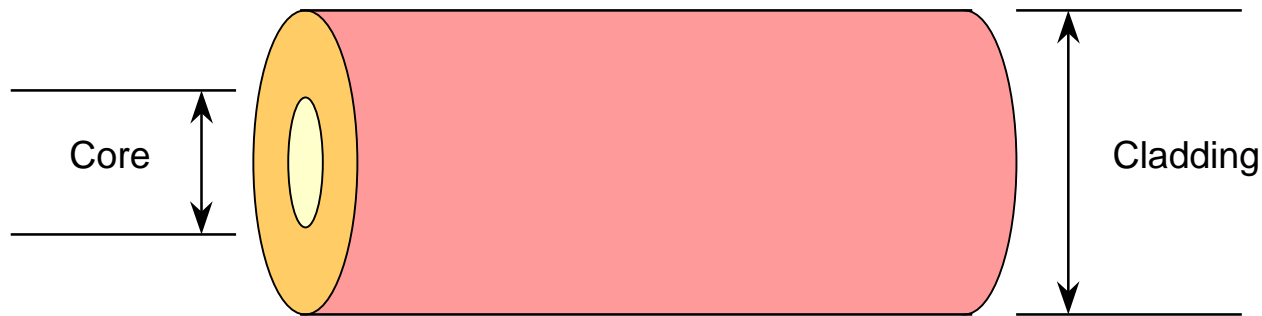
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Optical Fibre Construction

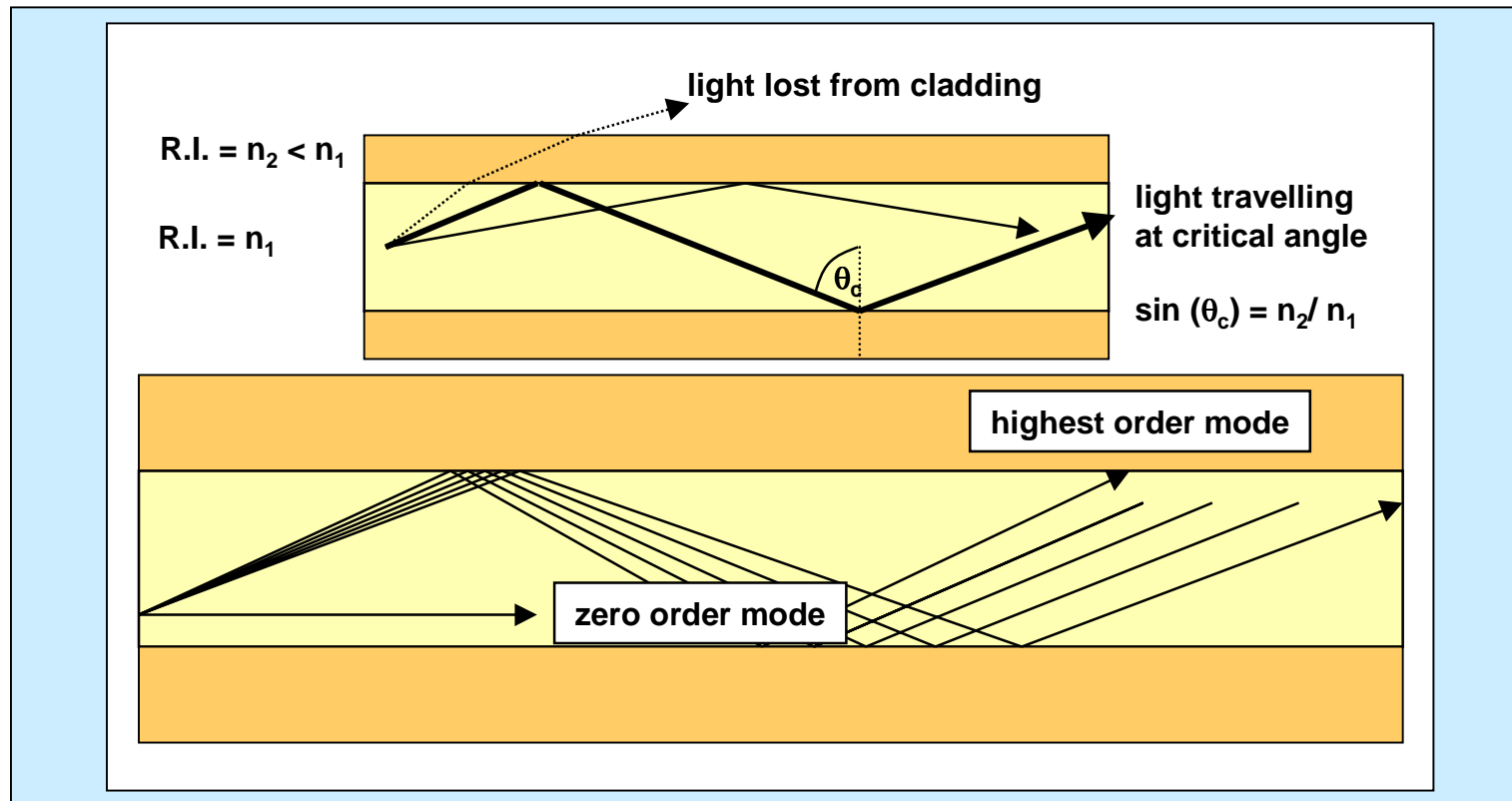


Core and cladding have different optical properties

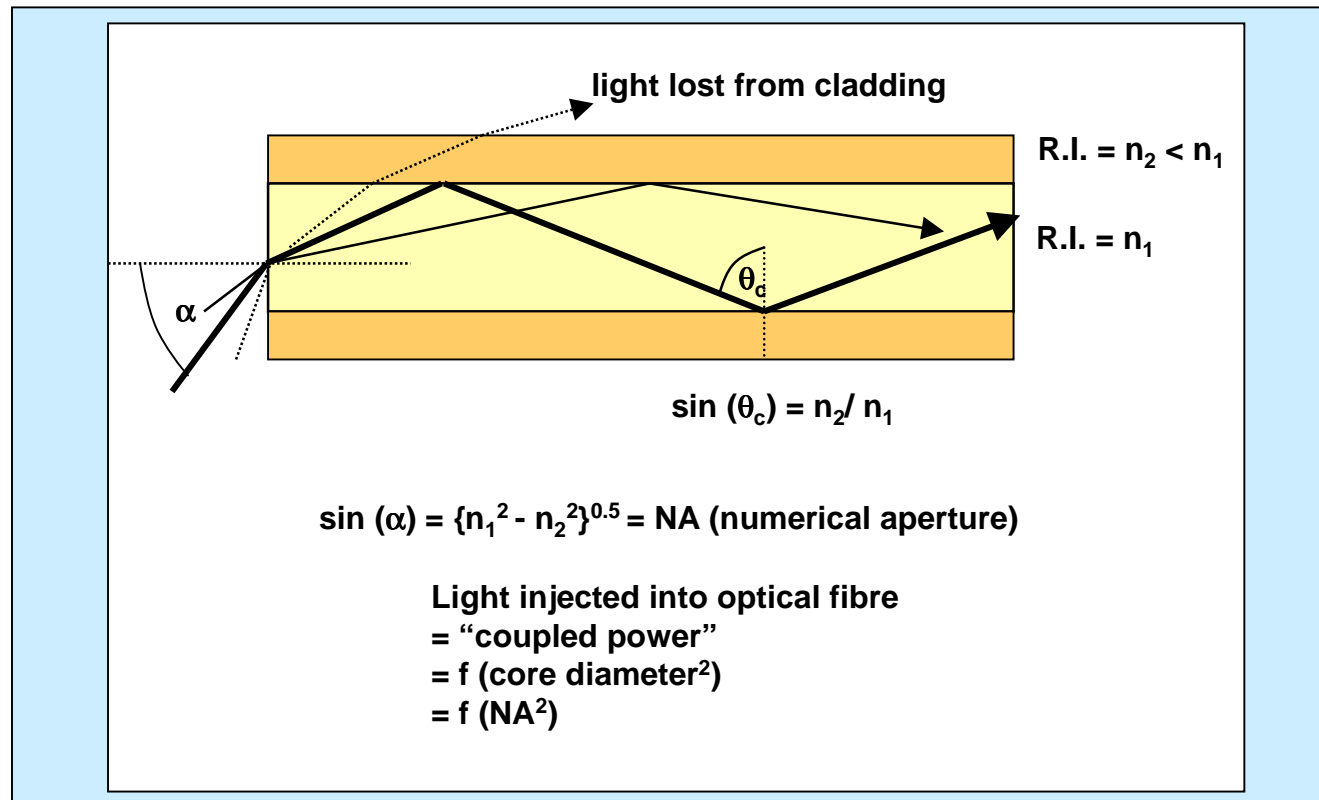
Refractive index (R.I.) $n_x = c/v_x$
c = speed of light in a vacuum
v_x = speed of light in material x

Light is transmitted in the core when $n_{\text{core}} > n_{\text{cladding}}$

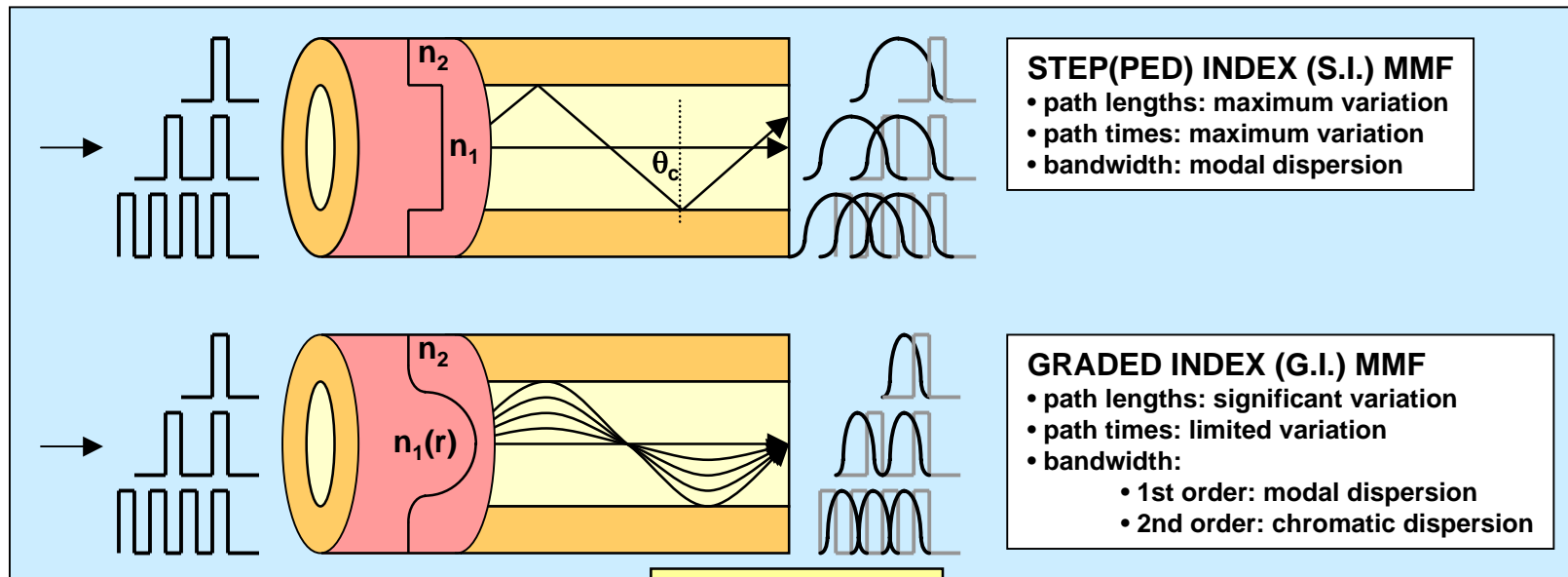
Total Internal Reflection



Acceptance Angle: N.A.

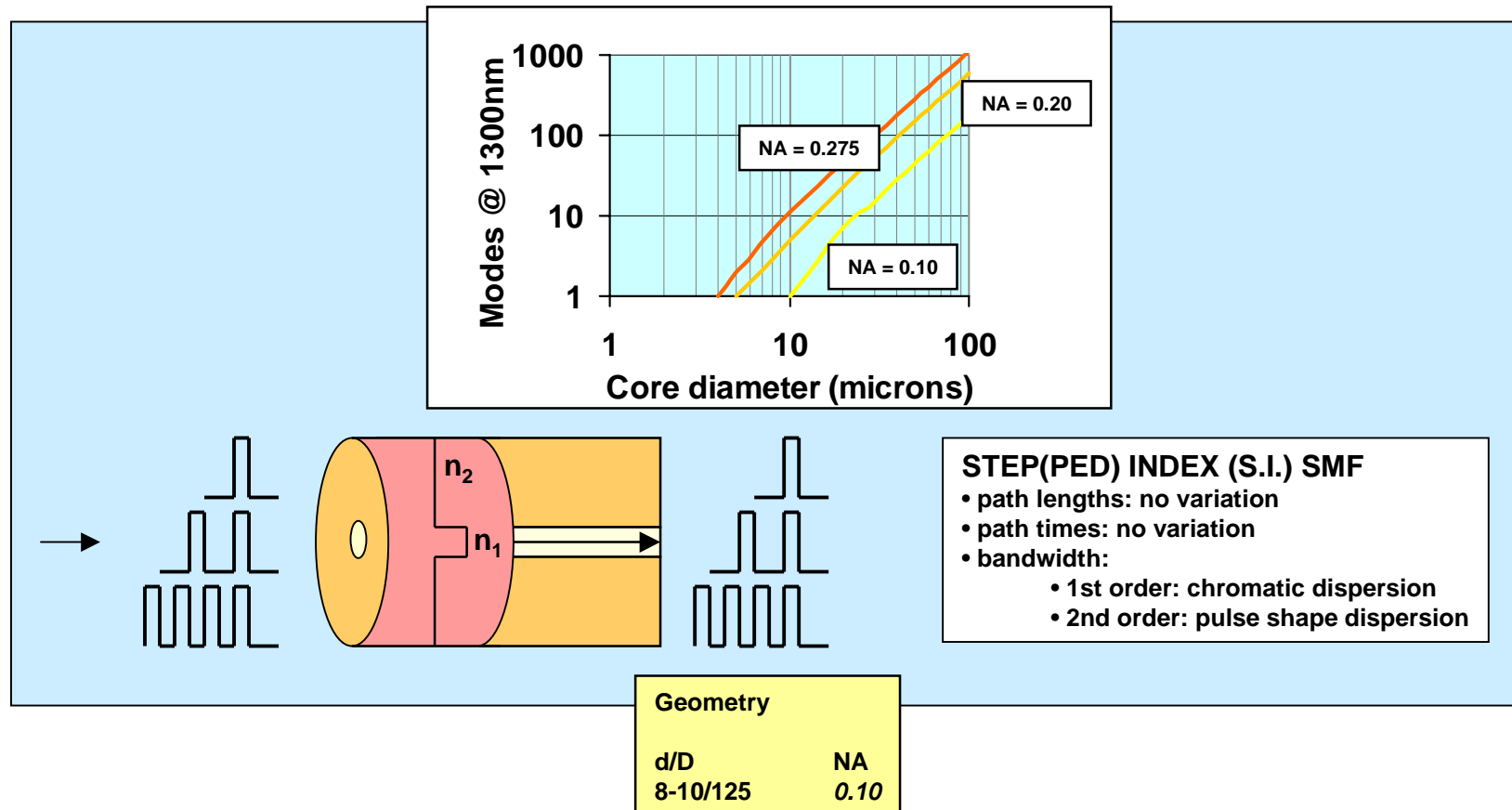


MMF: Multimode Optical Fibre



| Geometry options | |
|------------------|-------|
| d/D | NA |
| 50/125 | 0.20 |
| 62.5/125 | 0.275 |

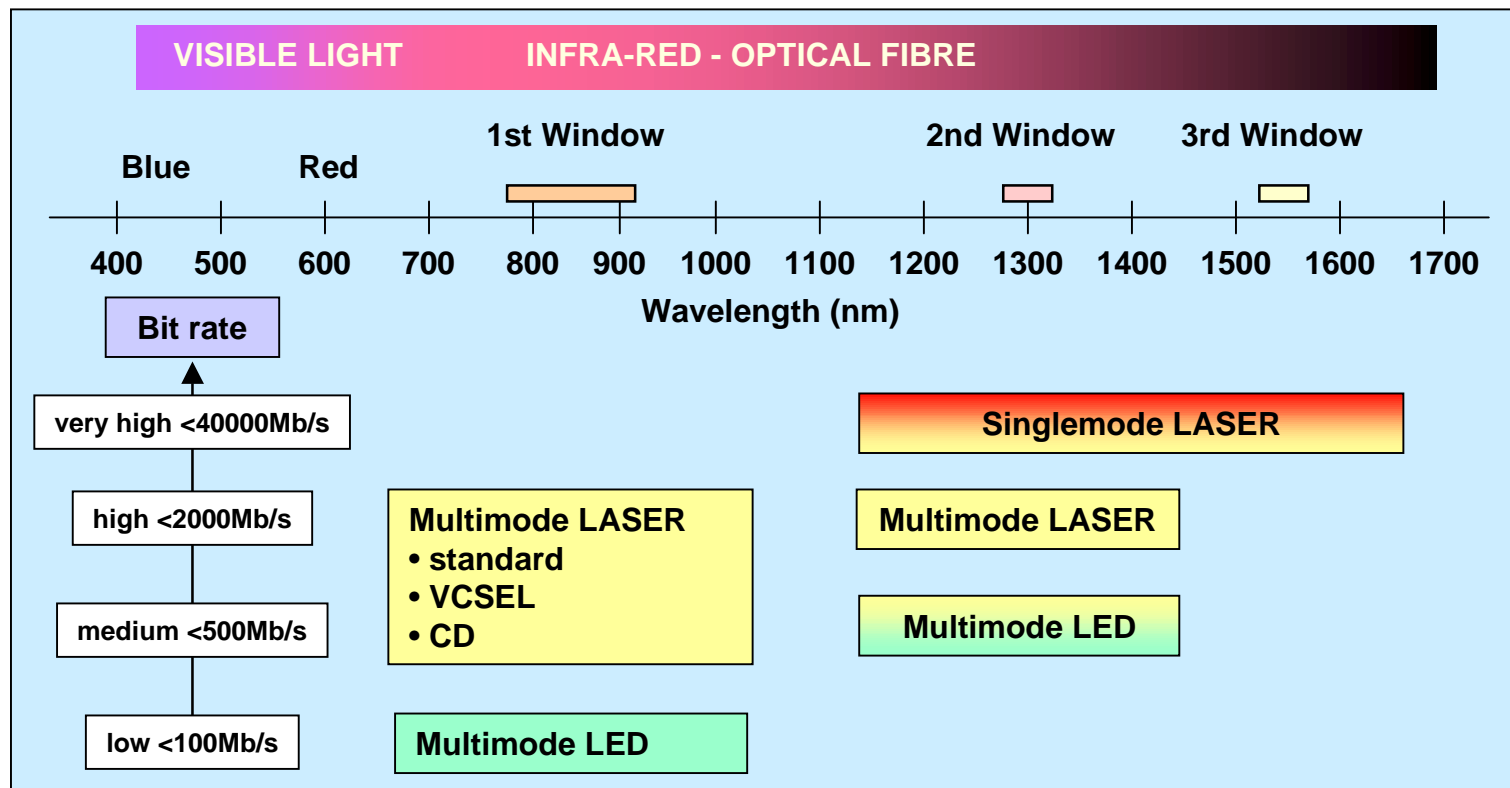
SMF: Singlemode Optical Fibre



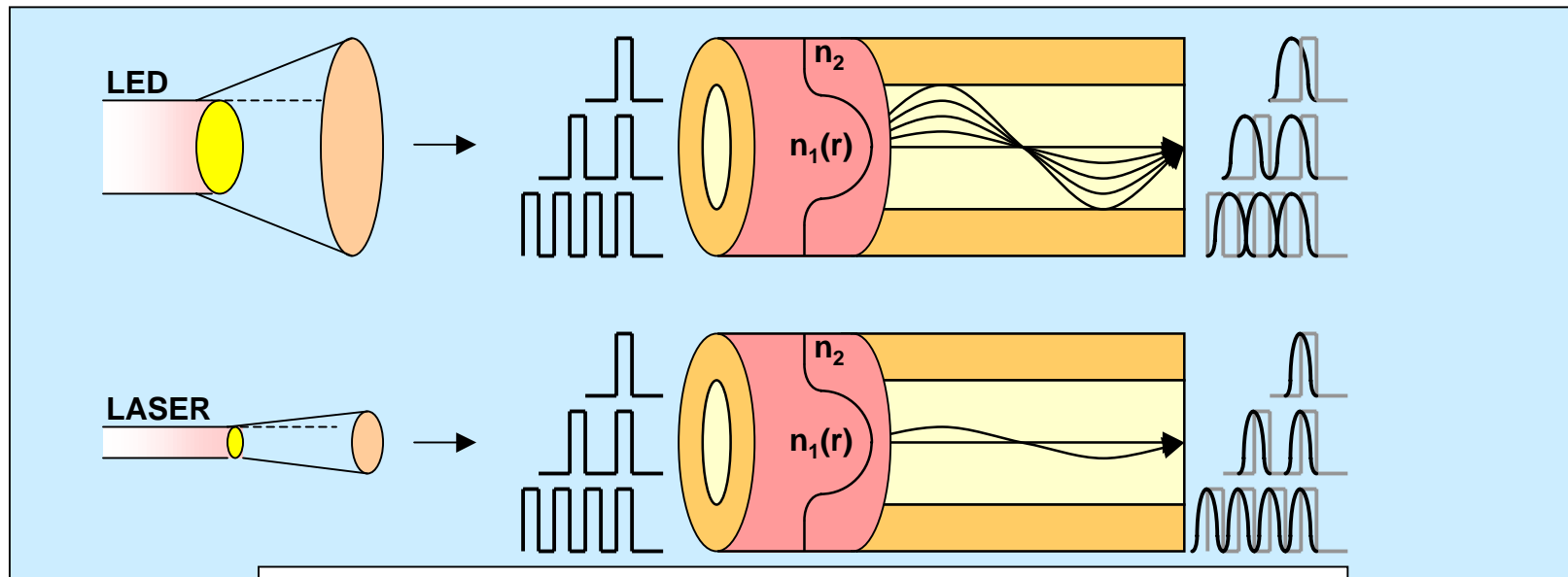
STEP(PED) INDEX (S.I.) SMF

- path lengths: no variation
- path times: no variation
- bandwidth:
 - 1st order: chromatic dispersion
 - 2nd order: pulse shape dispersion

Injection Devices



MMF Bandwidth: LASER-LED



LASER devices should be able to offer higher data rates
over a given MMF

-
theoretically

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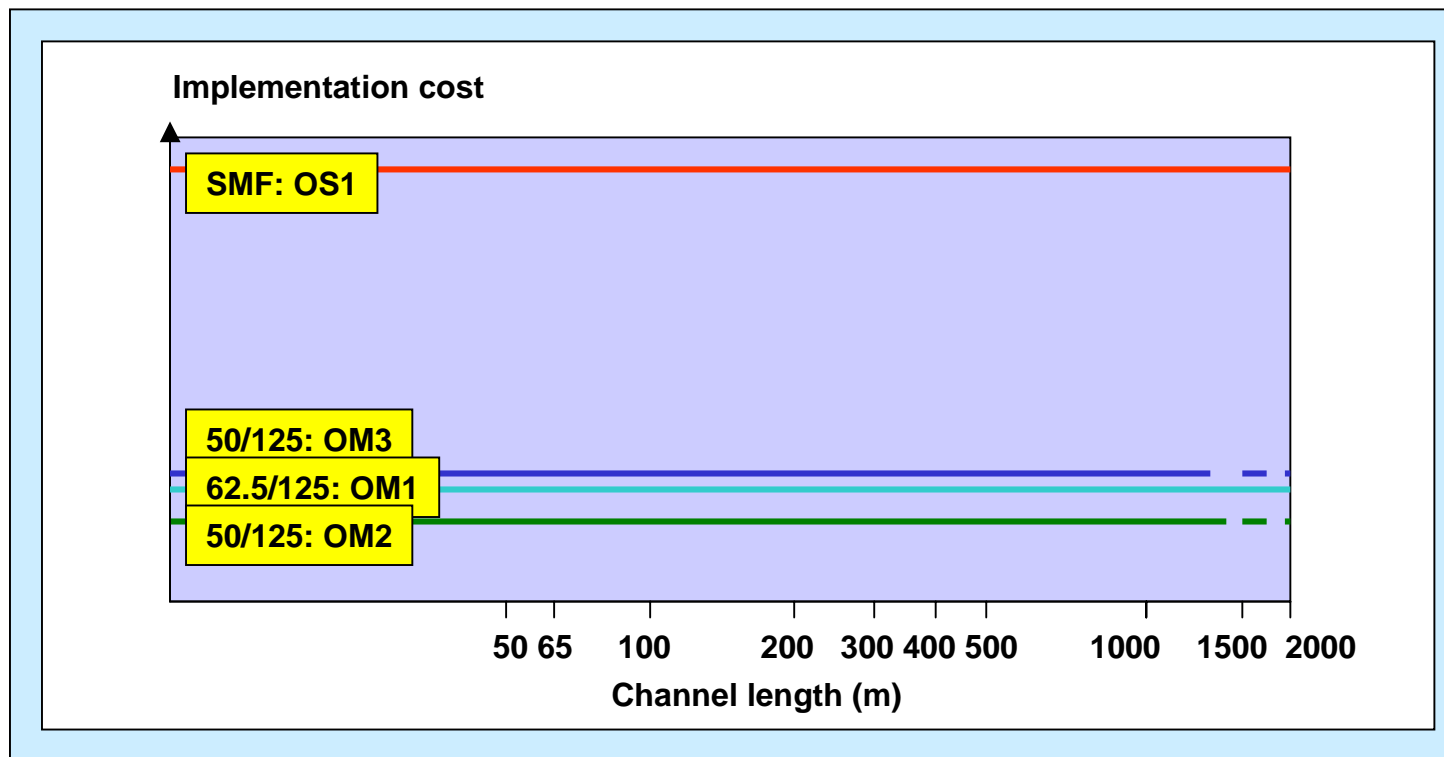
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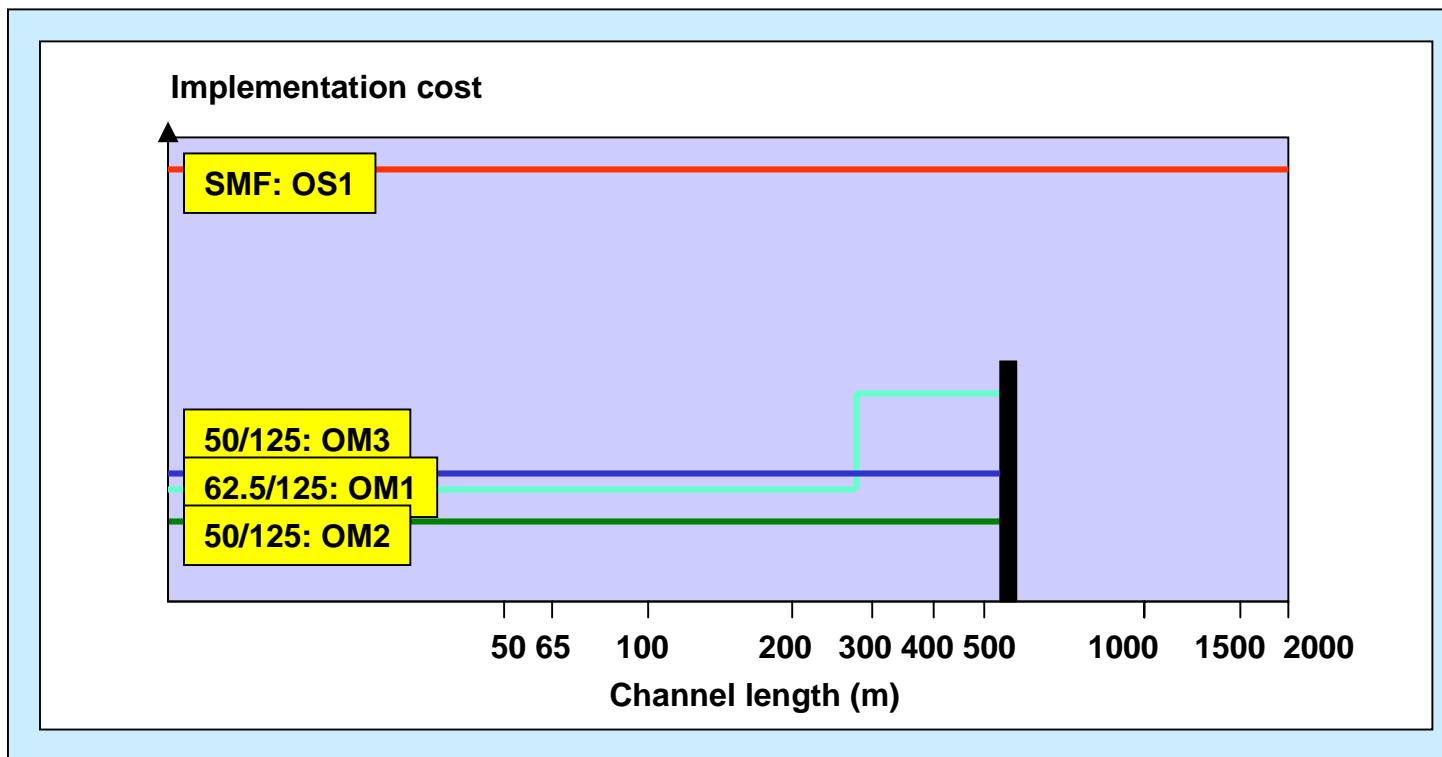
Future FIA publications

End

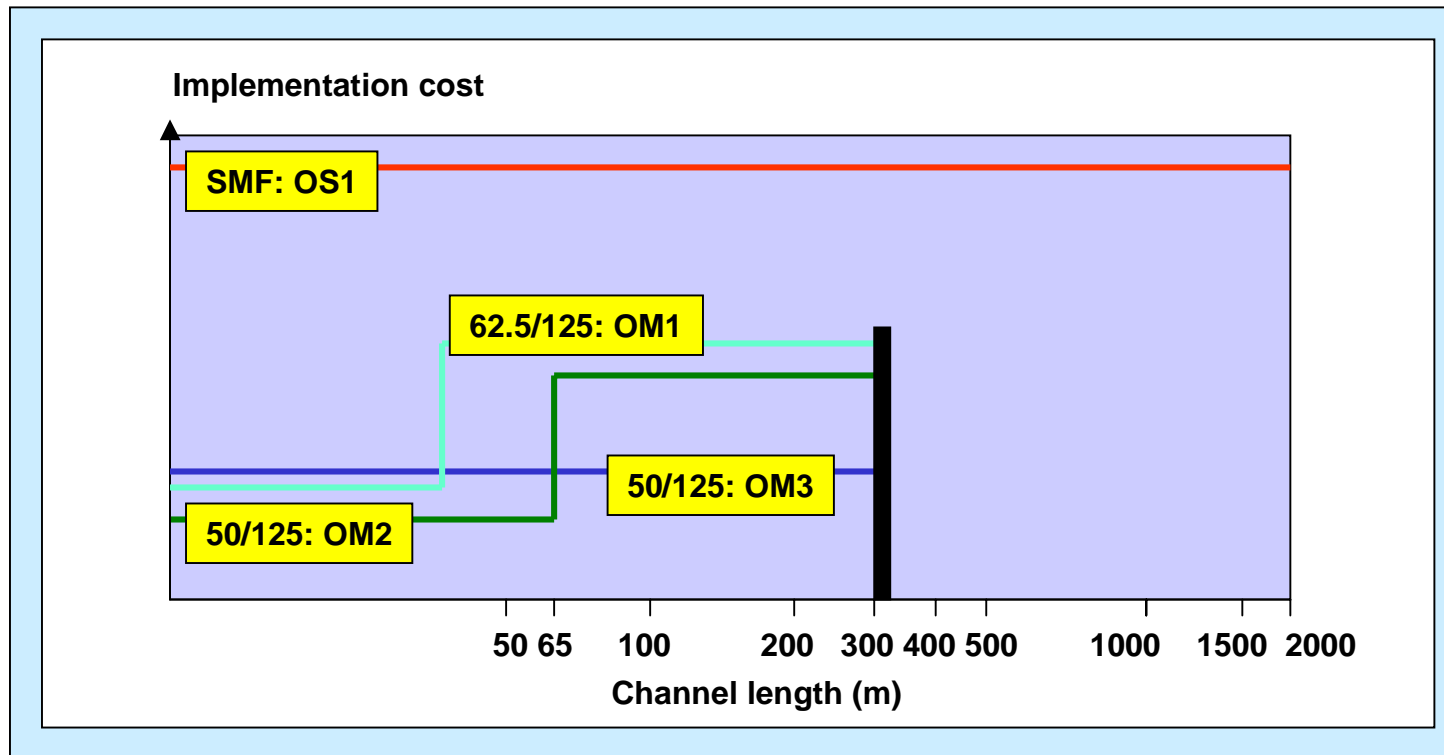
100Mb/s Implementation



1000Mb/s Implementation



10000Mb/s Implementation





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Milestones

Establish test method references for inclusion in
ISO/IEC 11801 (2002) and BS EN 50173 (2002)

Develop consensus on
overfilled launch (OFL) - restricted mode launch (RML) bandwidth
requirements

Notify various application groups
with recommendation to consider the
enhanced performance that may be possible

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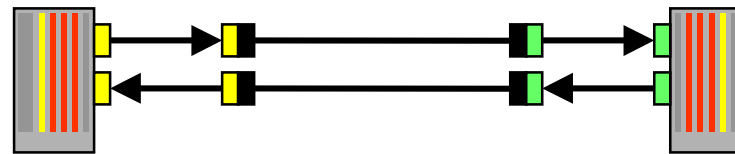
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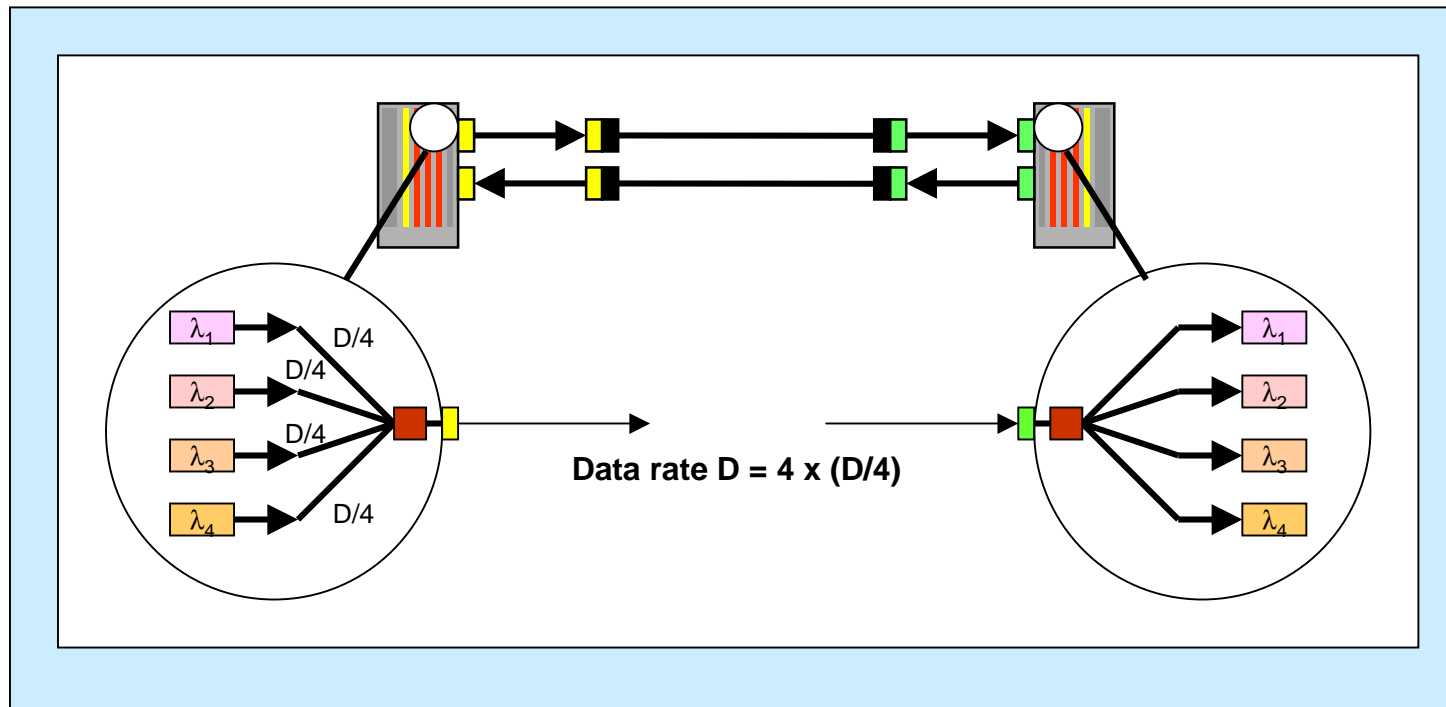
10 Gigabit Ethernet



- switched operation only
- star topology
- support 10Gb/s Ethernet and 9.584640Gb/s SONET
- 2000 m, 10000 m and 40000 m over SMF
- 100 m over existing MMF

| | Range | OF | Wavelength | Cable | Protocol | |
|----------------|-----------|-----|------------|-------|----------|-------|
| Legacy support | < 35 m | MMF | 850 | OM1 | Serial | SAN |
| | < 69 m | MMF | 850 | OM2 | Serial | |
| | < 300 m | MMF | 850 | OM3 | Serial | |
| Legacy support | < 300 m | MMF | 1300 | OMx | WWDM | LAN |
| | < 10000 m | SMF | 1310 | OS1 | Serial | |
| | < 40000 m | SMF | 1550 | OS1 | Serial | M/WAN |

WWDM



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OF LAN Applications

| STANDARDIZED APPLICATIONS | Mb/s |
|--------------------------------|-------|
| ISO/IEC 8802-3: FOIRL | 10 |
| ISO/IEC 8802-3: 10BASE-FL/FB | 10 |
| ISO/IEC 8802-5: TR 4/16 Mb/s | 4/16 |
| IEEE 802-12: Demand priority | 100 |
| ATM-52 | 52 |
| CD 9314-9 FDDI-LCF | 100 |
| ISO/IEC 9314-3 FDDI | 100 |
| ISO/IEC DIS 9314-4 FDDI | 100 |
| ISO/IEC 8802-3: 100BASE-FX | 100 |
| TR 100 Mbit/s | 100 |
| ATM-155 | 155 |
| ATM-622 | 622 |
| CD 14165-1: Fibre Channel-133 | 133 |
| CD 14165-1: Fibre Channel-266 | 266 |
| CD 14165-1: Fibre Channel-531 | 531 |
| CD 14165-1: Fibre Channel-1062 | 1062 |
| IEEE 802-3: 1000BASE-SX | 1000 |
| IEEE 802-3: 1000BASE-LX | 1000 |
| APPLICATIONS IN DEVELOPMENT | |
| IEEE 802-3: 10000BASE-?? | 10000 |
| IEEE 802-3: 10000BASE-?? | 10000 |

APPLICATION FUNCTION

```

graph TD
    A[APPLICATION FUNCTION] --> B[SIGNAL CLARITY]
    A --> C[PROTOCOL FUNCTION]
    B --> D[Attenuation]
    B --> E[Dispersion]
    C --> F[Delay]
    
```

ATTENUATION

Copper:

- connection ~ 2 metres of cable length

Optical fibre:

- connection ~ 150-500 metres of cable length
- splice ~ 100-300 metres of cable length

DISPERSION

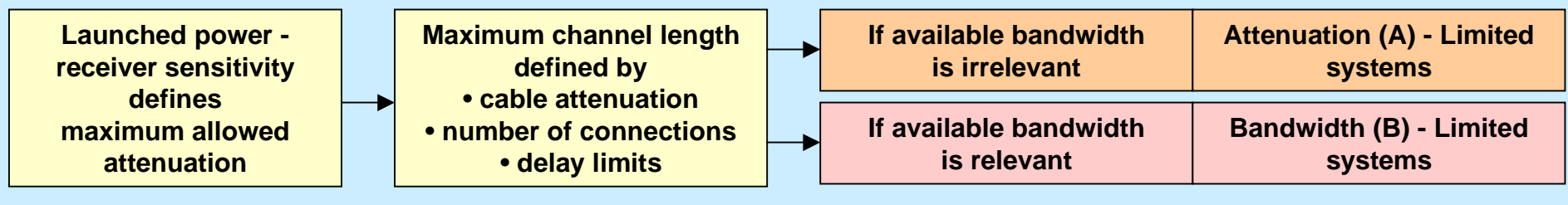
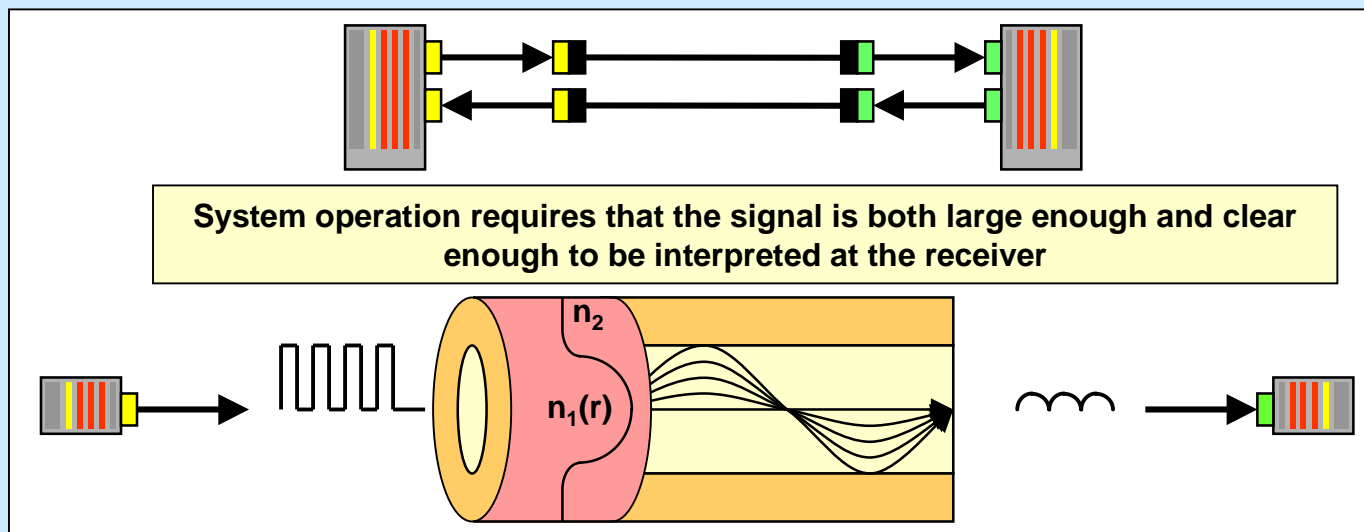
Copper:

- dispersion irrelevant - noise critical

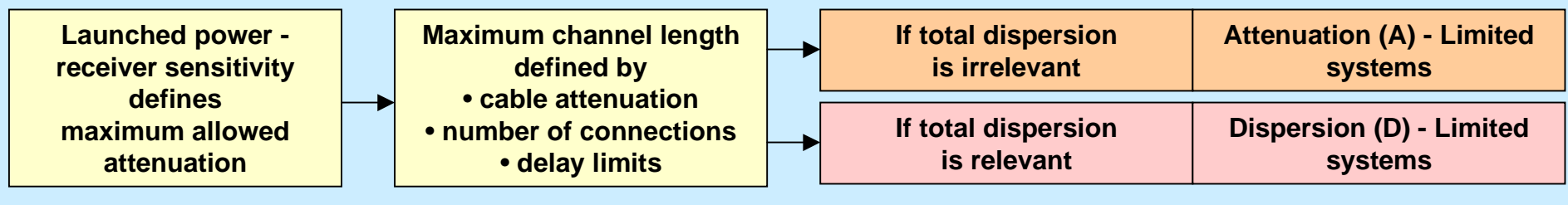
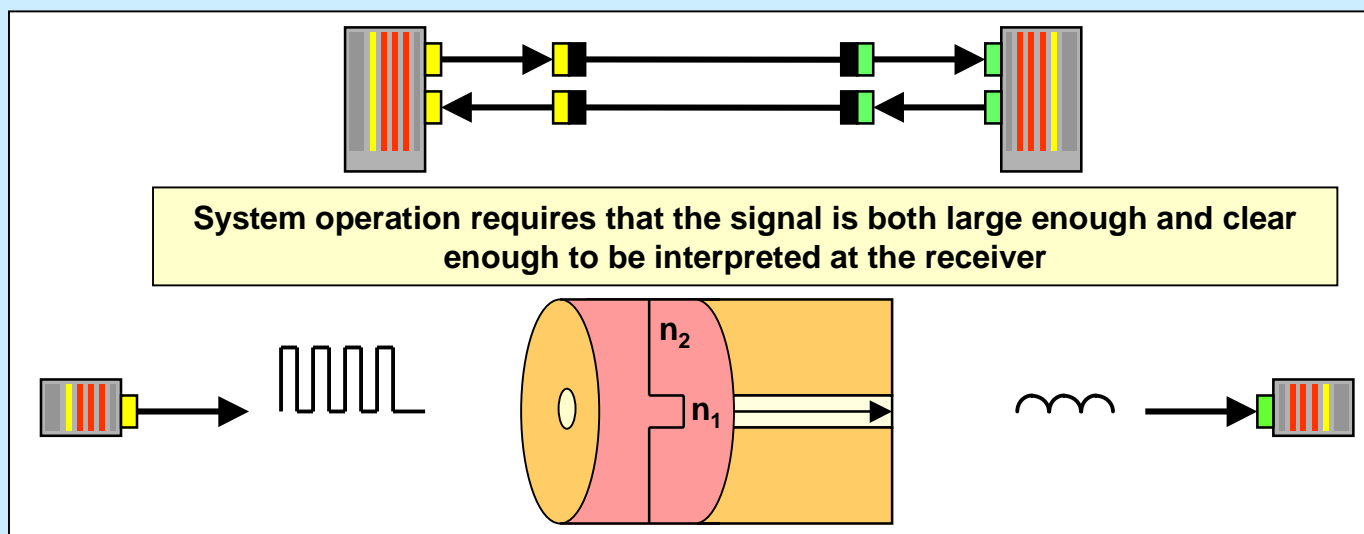
Optical fibre:

- noise irrelevant
- dispersion irrelevant for low bit rate applications
- dispersion critical for high bit rate applications

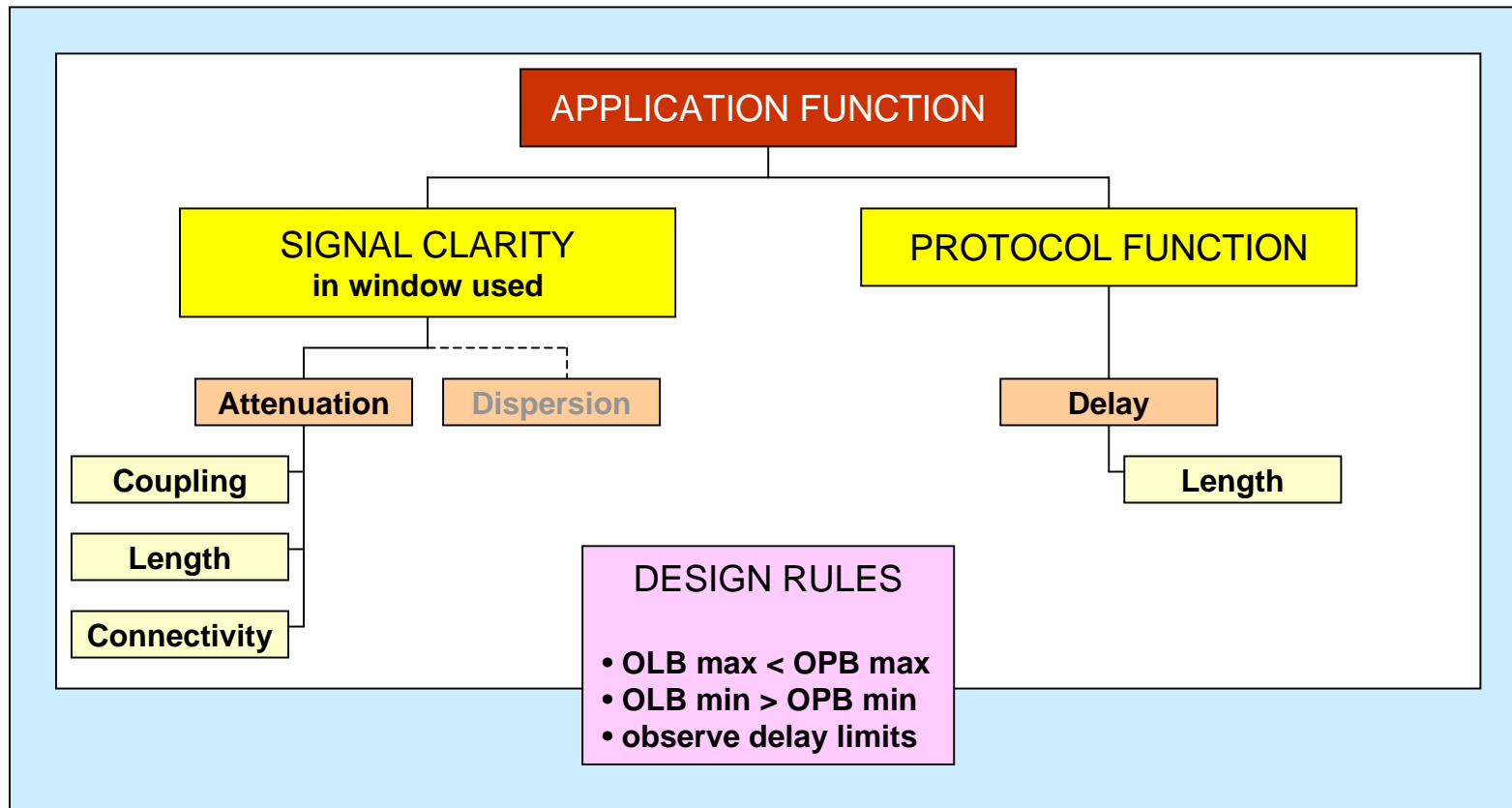
MMF Systems



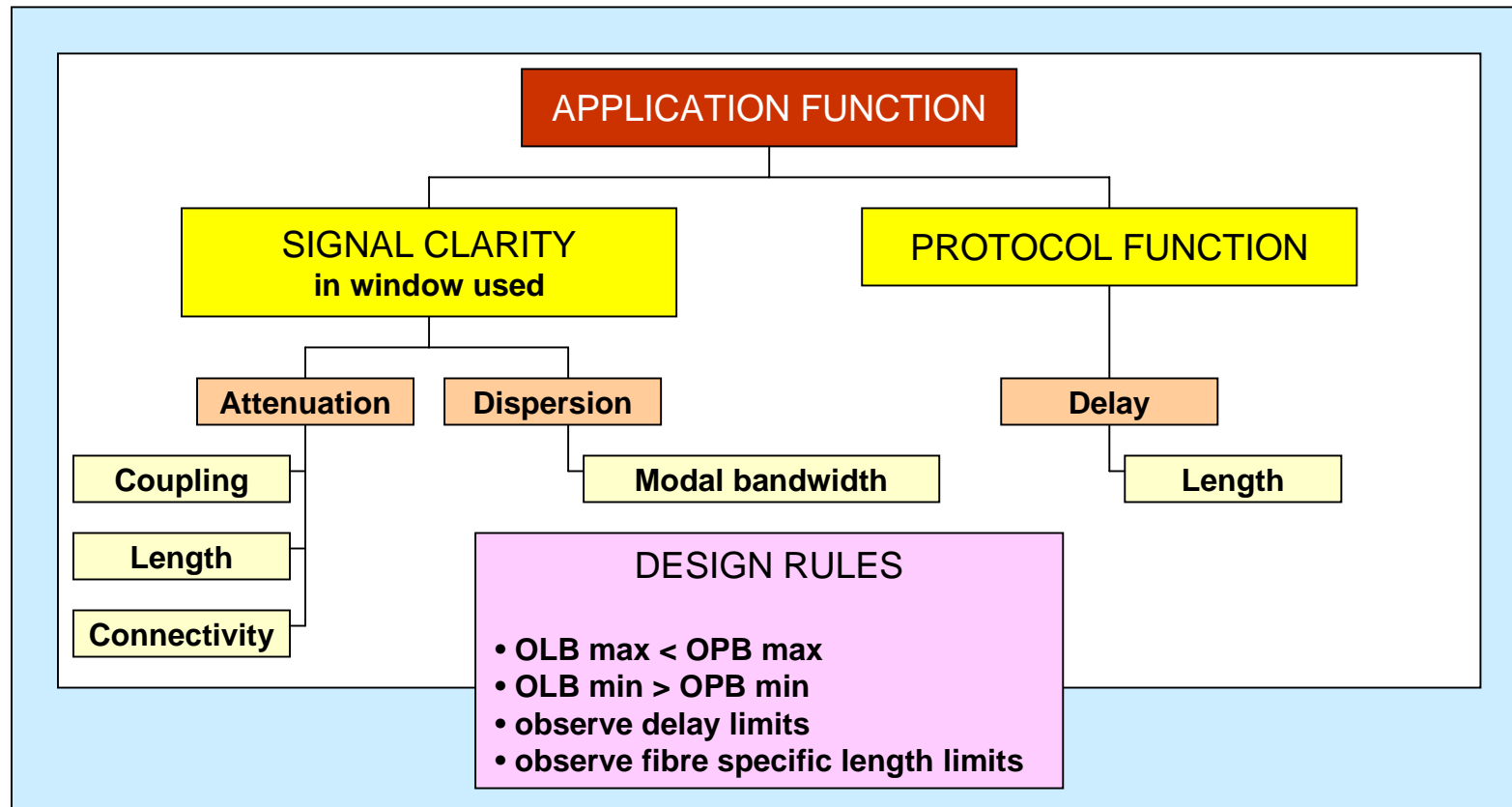
SMF Systems



A-Limited System Design Rules



B-Limited System Design Rules



A-Limited MMF LAN standards

Limit defined in LAN standard

| | | 50/125 (OMx) | | 62.5/125 (OMx) | | OPB Δ (dB) |
|---------|--|-------------------|---------------|-----------------|---------------|------------|
| | | Max. length (m) | OPB max. (dB) | Max. length (m) | OPB max. (dB) | |
| 850 nm | ISO/IEC 8802-3: FOIRL | 514 ¹ | 3.3 | 1000 | 9.0 | 5.7 |
| | ISO/IEC 8802-3: 10BASE-FL/FB | 1514 ¹ | 6.8 | 2000 | 12.5 | 5.7 |
| | ISO/IEC TR 11802-4: 4 & 16 Mb/s Token Ring | 1857 ¹ | 8.0 | 2000 | 13.0 | 5.0 |
| 1300 nm | ISO/IEC 9314-3: FDDI PMD | 2000 | 6.0 | 2000 | 11.0 | 5.0 |
| | ISO/IEC 8802-3: 100BASE-FX | 2000 | 6.0 | 2000 | 11.0 | 5.0 |
| | IEEE 802.12: Demand priority | 533 ¹ | 2.3 | 2000 | 7.0 | 4.7 |
| | ATM @ 52 Mb/s | 2000 | 5.3 | 2000 | 10.0 | 4.7 |
| | ATM @ 155 Mb/s | 2000 | 5.3 | 2000 | 10.0 | 4.7 |

¹ Calculated values using 1.5dB of connecting hardware losses

62.5/125 seems to offer advantages

B-limited LAN standards

| | | 50/125 (OM2) 500/500MHz.km | | 62.5/125 (OM1) 200/500MHz.km | | OPB Δ (dB) |
|---|---|----------------------------------|---------------------|---------------------------------|---------------------|------------------|
| | | Max. length (m) | OPB max. (dB) | Max. length (m) | OPB max. (dB) | |
| 850 nm | IEEE 802.12: Demand priority | 371 ¹ | 2.8 | 500 | 7.5 | 4.7 |
| | ATM @ 155 Mb/s | 1000 | 7.2 | 1000 | 7.2 | 0.0 |
| | CD 14165: FibreChannel @ 266 Mb/s | 2000 | 12.0 | 700 | 12.0 | 0.0 |
| | CD 14165: FibreChannel @ 531 Mb/s | 1000 | 8.0 | 350 | 8.0 | 0.0 |
| | ATM @ 622 Mb/s | 300 | 4.0 | 300 | 4.0 | 0.0 |
| | IEEE 802.3: 1000BASE-SX: Gigabit Ethernet | 550 | 3.56 | 275 | 2.6 | - 0.96 |
| | CD 14165: FibreChannel @ 1062 Mb/s | 500 | 4.0 | 300 | 4.0 | 0.0 |
| 1300 nm | CD 14165: FibreChannel @ 133 Mb/s | 371 ¹ | 1.3 | 1500 | 6.0 | 4.7 |
| | CD 14165: FibreChannel @ 266 Mb/s | 2000 | 5.5 | 1500 | 6.0 | 0.5 |
| | ATM @ 622 Mb/s | 330 | 2.0 | 500 | 6.0 | 4.0 |
| | IEEE 802.3: 1000BASE-LX: Gigabit Ethernet | >550 | 2.35 | 550 | 2.35 | 0.0 |
| ¹ Assuming no connecting hardware loss | | 50/125 seems to offer advantages | | | | |

A-Limited SMF LAN standards

Limits defined in LAN standard

| | | SMF (OS1) | |
|---------|---|-----------------|---------------|
| | | Max. length (m) | OPB max. (dB) |
| 1300 nm | IEEE 802.3: 1000BASE-LX: Gigabit Ethernet | 5000 | 4.56 |

Unallocated margin and OPB

| | | 850 nm | | | | 1300 nm | | | 1310 nm |
|--|------------------------------------|-------------|------------|------------|------------|-------------|------------|------------|-------------|
| | | 62.5 | | 50 | | 62.5 | 50 | | SMF |
| OFL Modal Bandwidth (MHz.km) | | 160 | 200 | 400 | 500 | 500 | 400 | 500 | |
| Assumed OF attenuation (dBkm ⁻¹) | | 3.75 | 3.75 | 3.50 | 3.50 | 1.5 | 1.5 | 1.5 | 0.5 |
| | | 1000BASE-SX | | | | 1000BASE-LX | | | |
| | | 830 nm | | | | 1270 nm | | 1270 nm | |
| A | Max. channel length (m) | 220 | 275 | 500 | 550 | 550 | 550 | 550 | 5000 |
| | Max. OF cable attenuation (dB) | 0.88 | 1.1 | 1.87 | 2.06 | 0.85 | 0.85 | 0.85 | 3.07 |
| | Connecting hardware allowance (dB) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| B | Max.length channel loss (dB) | 2.38 | 2.60 | 3.37 | 3.56 | 2.35 | 2.35 | 2.35 | 4.57 |
| C | Equipment OPB (dB) | 7.5 | | | | 7.5 | | | 8.0 |
| D | Power penalty (dB) | 4.27 | 4.29 | 4.07 | 3.57 | 3.48 | 5.08 | 3.96 | 3.27 |
| B | Total channel loss (dB) | 2.38 | 2.60 | 3.37 | 3.56 | 2.35 | 2.35 | 2.35 | 4.57 |
| E=C-D-B | Unallocated margin (dB) | 0.84 | 0.60 | 0.05 | 0.37 | 1.67 | 0.07 | 1.19 | 0.16 |

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Next steps

2000 SERIES DOCUMENT SET

DESIGN

OPTICAL FIBRE CABLING: LAN APPLICATION SUPPORT GUIDE
OPTICAL FIBRE CABLING: WAN APPLICATION SUPPORT GUIDE

OPERATION

OPTICAL FIBRE CABLING: QUALITY ASSURANCE
OPTICAL FIBRE CABLING: ADMINISTRATION

INSTALLATION

OPTICAL FIBRE CABLING: INSTALLATION PRACTICE
OPTICAL FIBRE CABLING: TESTING

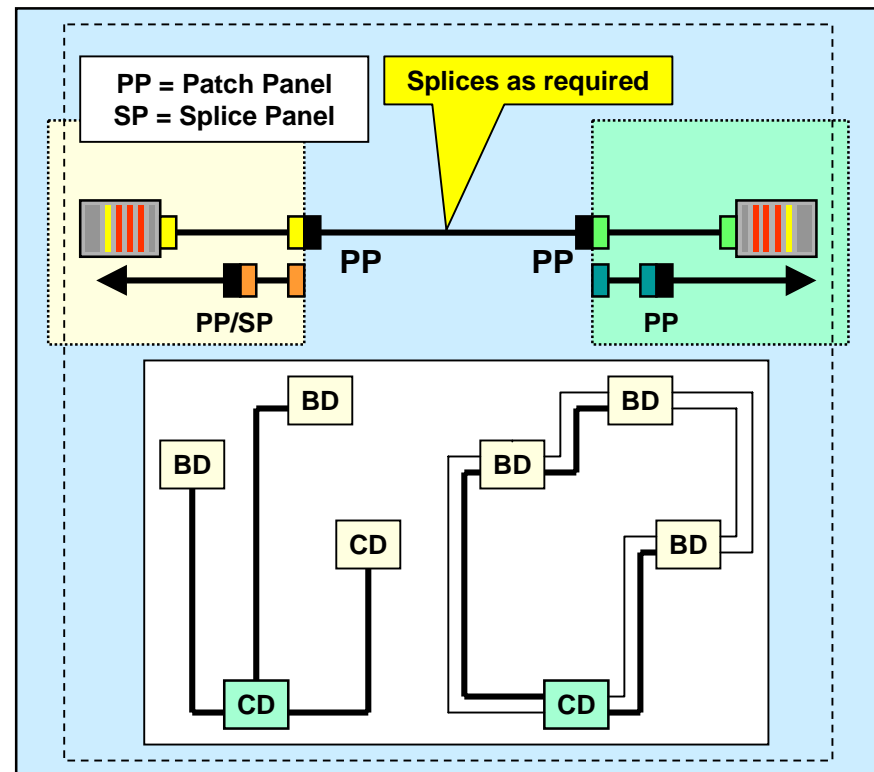
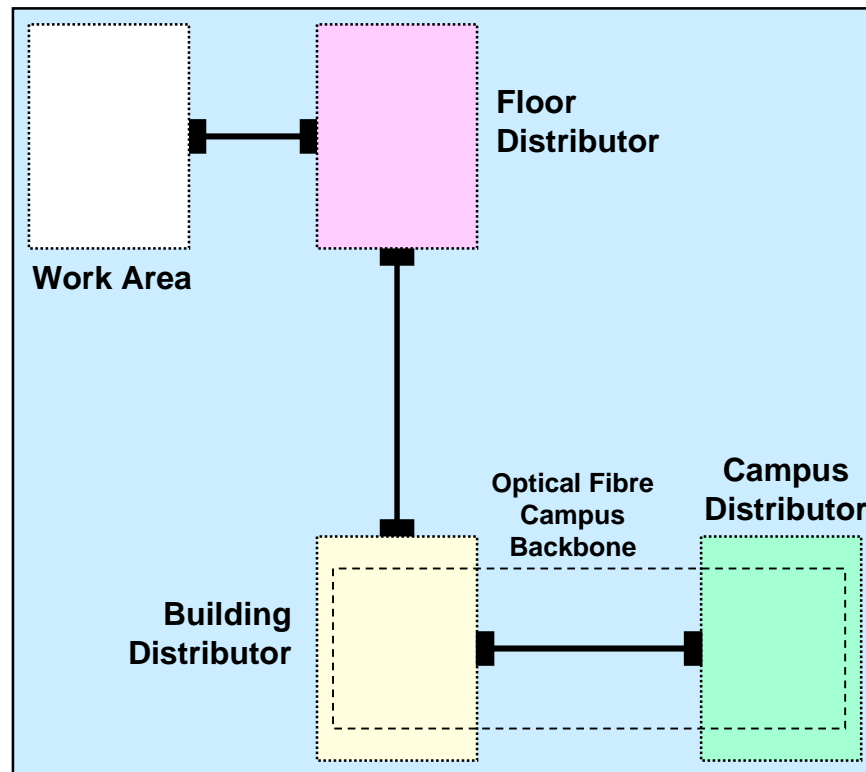
SAFETY

OPTICAL POWER: SAFETY LEVELS
OPTICAL FIBRE: HANDLING OF PROCESSING CHEMICALS
OPTICAL FIBRE: DISPOSAL OF WASTE

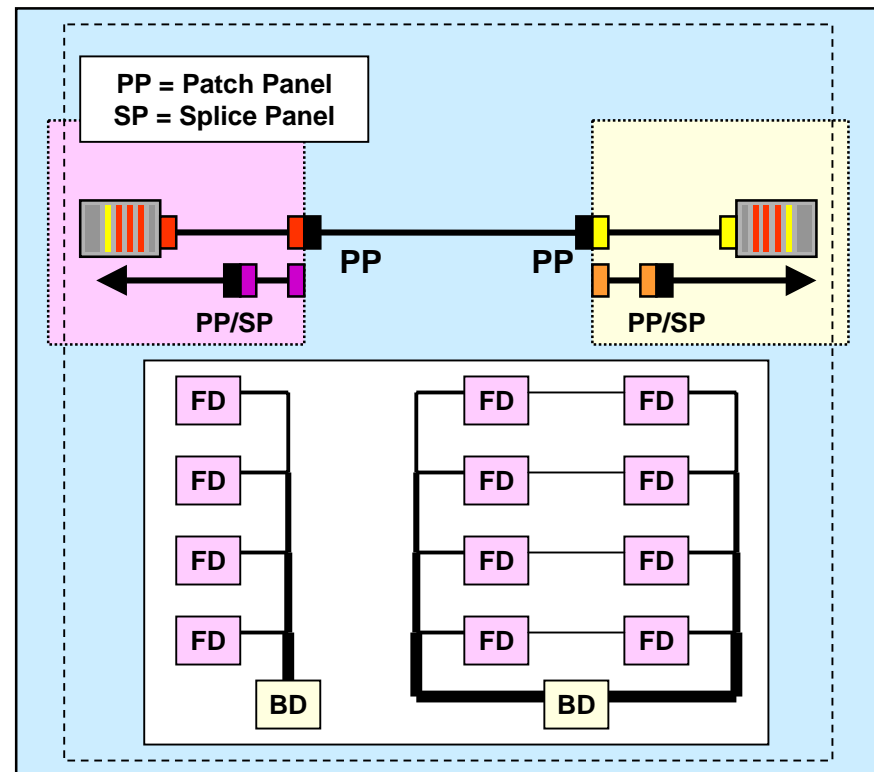
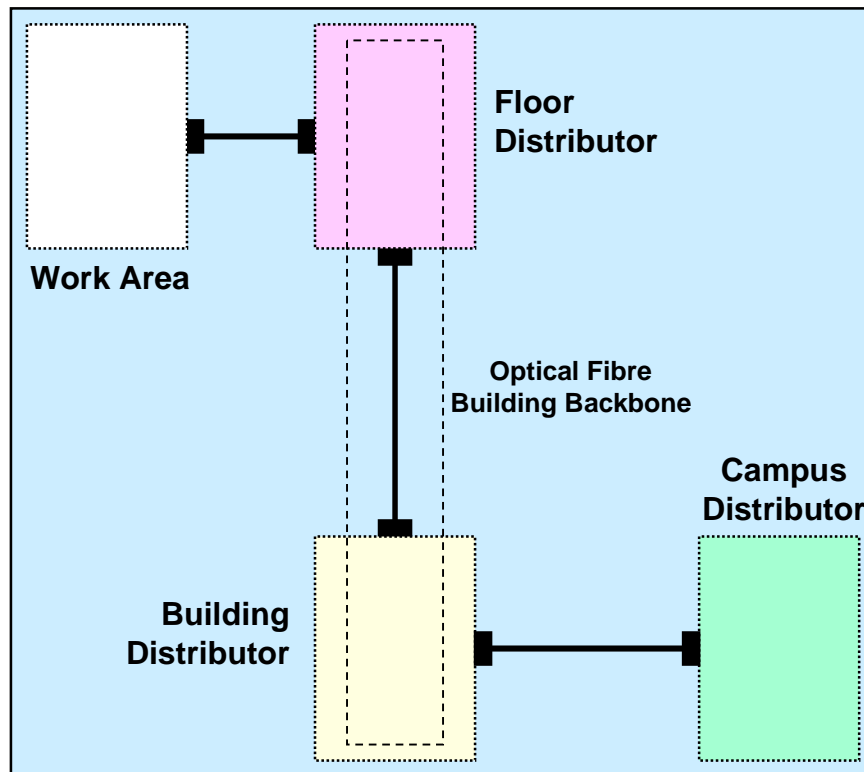
MODELLING TOOLS

CABLING STRUCTURES COST MODEL

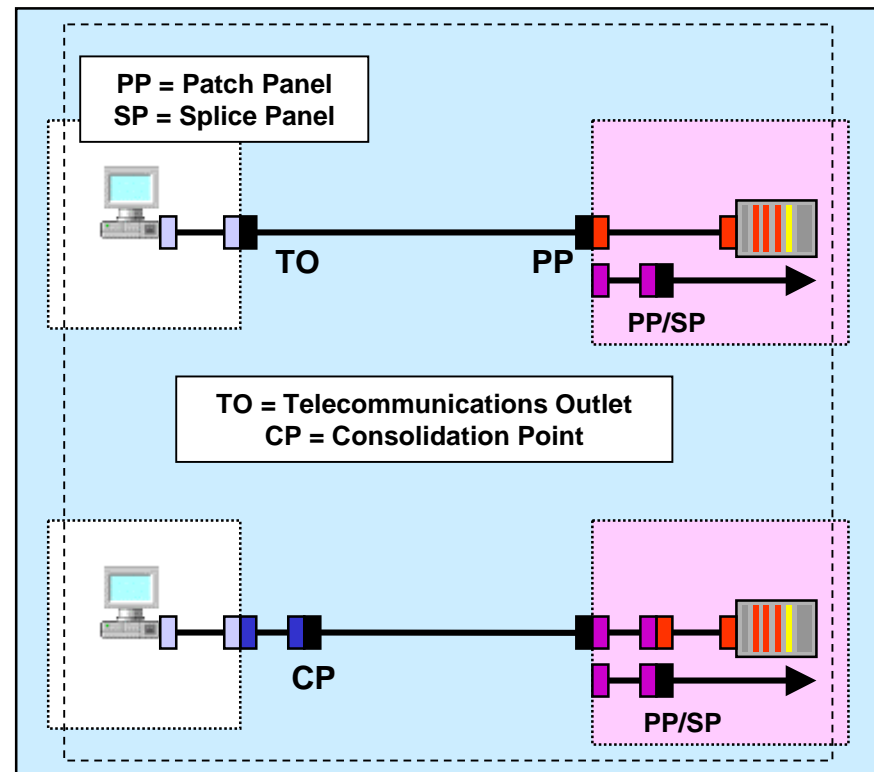
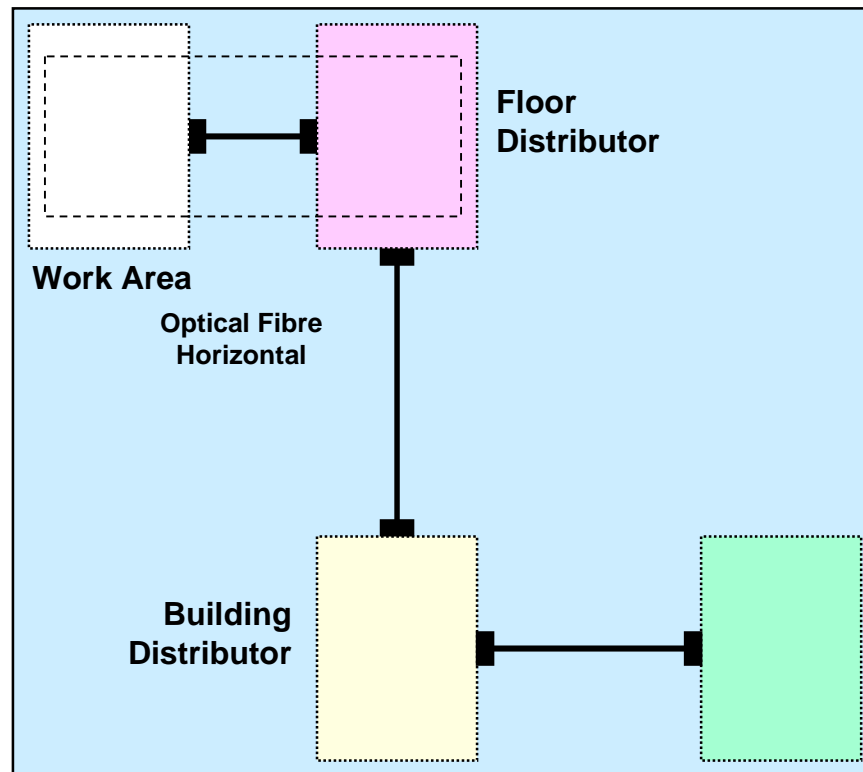
Campus Backbone Cabling



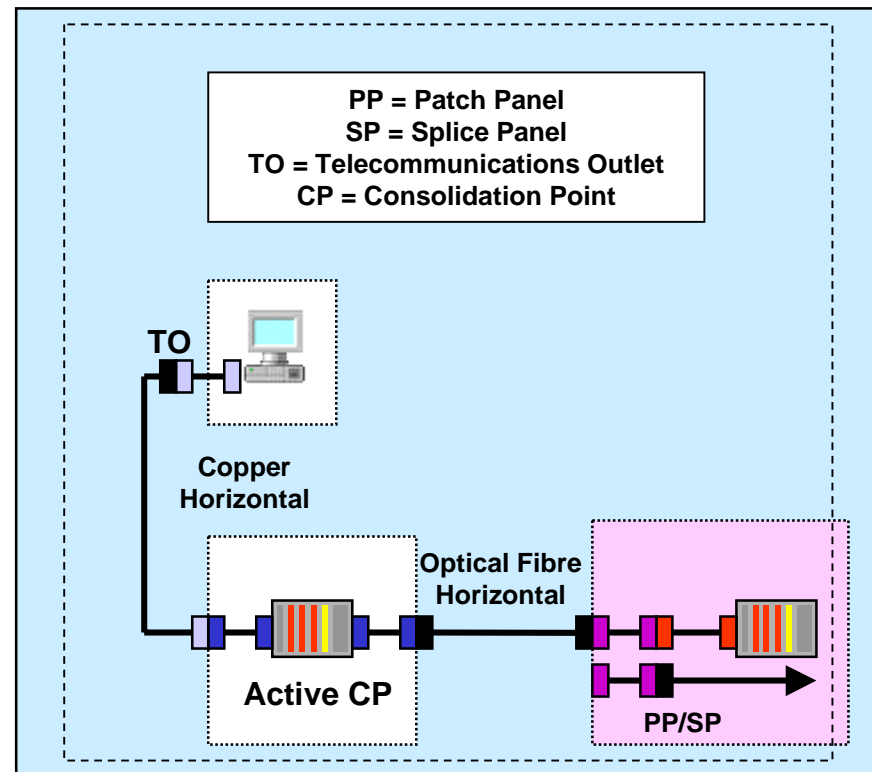
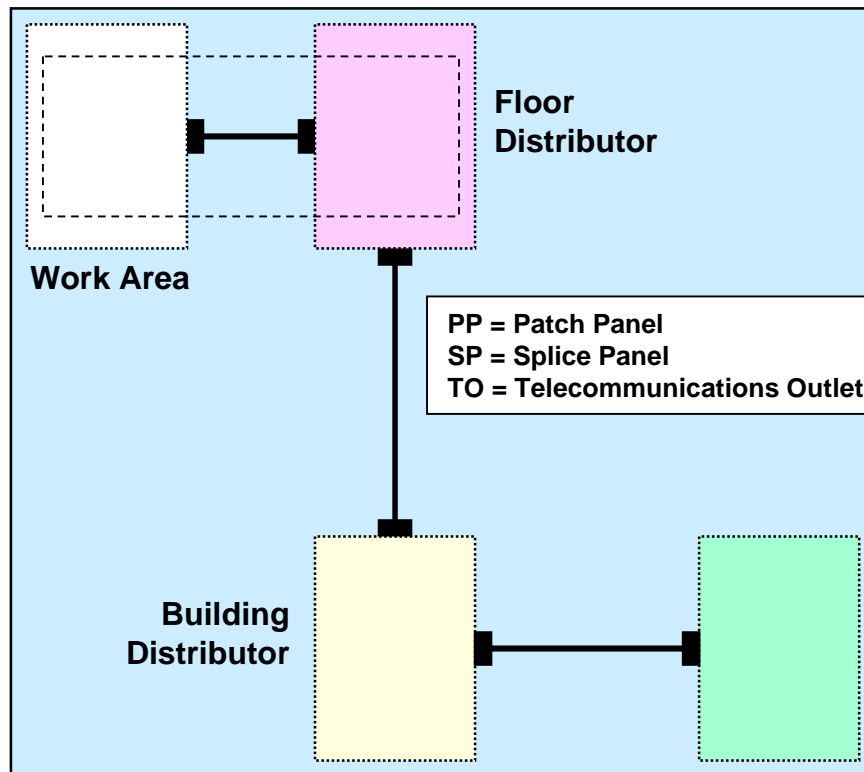
Building Backbone Cabling



Horizontal Cabling



New Structures - Active CP



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