

FIA Breakfast Seminar - March 2001
The New Optical Fibre Categories

THE NEW OPTICAL FIBRE CATEGORIES
What do they promise?

prepared and delivered
by



FIA Breakfast Seminar
13th March 2001

The Cabling Partnership
www.it-cabling.com
Presentations 2001

THE NEW OPTICAL FIBRE CABLE CATEGORIES

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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Standards

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"

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What are the new OF Categories?	10Gbit Ethernet "the grand plan"
Why do we need them?	FIA LAN ASG
What do they promise?	Future FIA publications
When can we have them?	End
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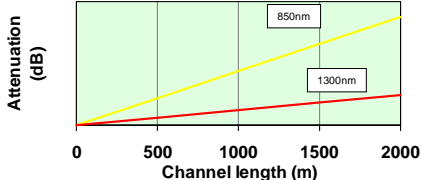
MMF Specification - I

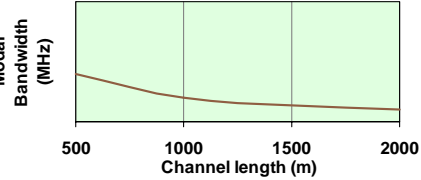


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Optical fibre geometry (standardized)				
	50/125		62.5/125	
Core diameter (µm)	50 ± 3		62.5 ± 3	
Cladding diameter (µm)	125 ± 3		125 ± 3	
NA	0.20 ± 0.015		0.275 ± 0.015	

Optical fibre performance parameters (options)			
Attenuation coefficient dBkm ⁻¹ max.		Modal bandwidth MHz.km min.	
850nm	1300nm	850nm	1300nm
?	?	?	?






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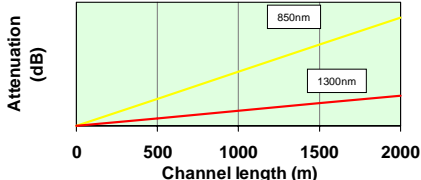
MMF Specification - II

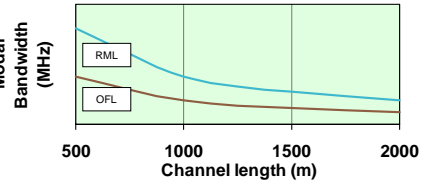


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Optical fibre performance parameters (options)					
Attenuation coefficient dBkm ⁻¹ max.		Modal bandwidth MHz.km min.		Modal bandwidth MHz.km min.	
850nm	1300nm	850nm	1300nm	850nm	1300nm
?	?	?	?	?	?
		Overfilled launch LED-like		Restricted launch LASER-like	






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MMF Performance Options '95




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	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	400	400	200	400	50/125 and 62.5/125
	2.5	0.8	400	600	200	600	
	2.7	1.0	400	800	160	200	
62.5/125	3.0	0.7	400	1000	200	200	62.5/125
	3.2	0.9	400	1200	250	1000	
			400	1500	300	800	
			600	1000			


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MMF Categories - 2002



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	Wavelength	50/125 or 62.5/125 Multimode OF		
		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	5		

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

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End

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Optical Fibre Construction



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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 $n_{\text{core}} > n_{\text{cladding}}$


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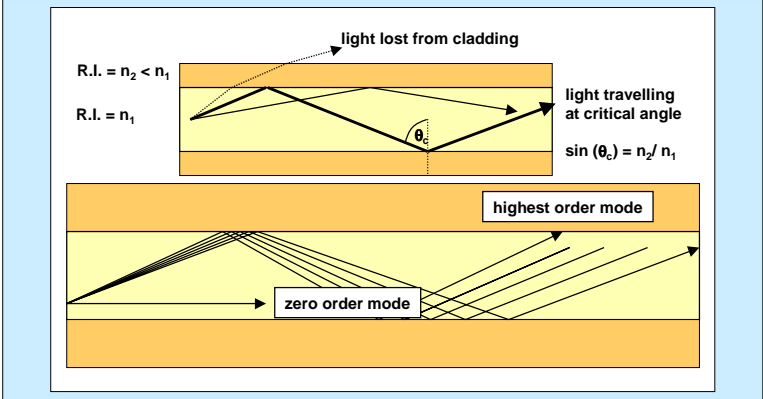
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Total Internal Reflection



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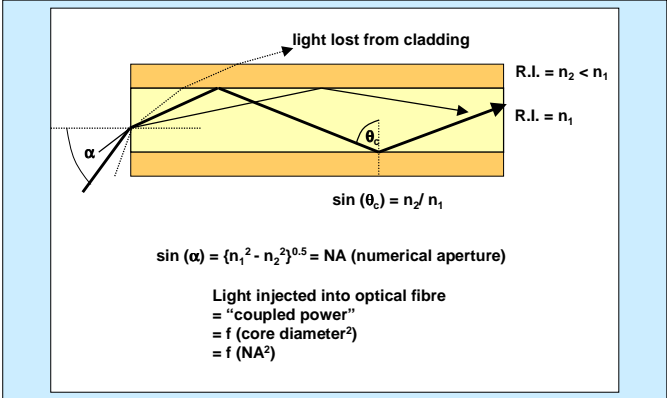
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Acceptance Angle: N.A.



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$\sin(\alpha) = \{n_1^2 - n_2^2\}^{0.5} = \text{NA (numerical aperture)}$

Light injected into optical fibre
= "coupled power"
= f (core diameter²)
= f (NA²)

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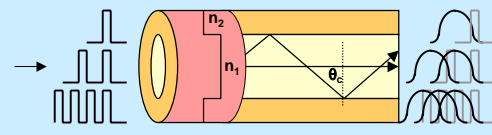
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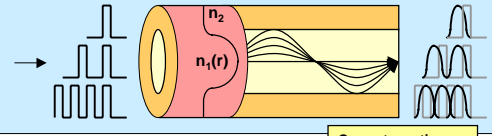
MMF: Multimode Optical Fibre





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

- path lengths: maximum variation
- path times: maximum variation
- bandwidth: modal dispersion



GRADED INDEX (G.I.) MMF

- path lengths: significant variation
- path times: limited variation
- bandwidth:
 - 1st order: modal dispersion
 - 2nd order: chromatic dispersion

Geometry options


d/D	NA
50/125	0.20
62.5/125	0.275

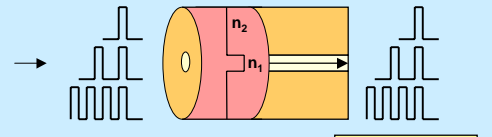
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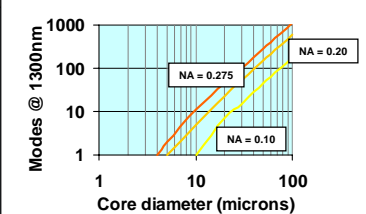
SMF: Singlemode Optical Fibre





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

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



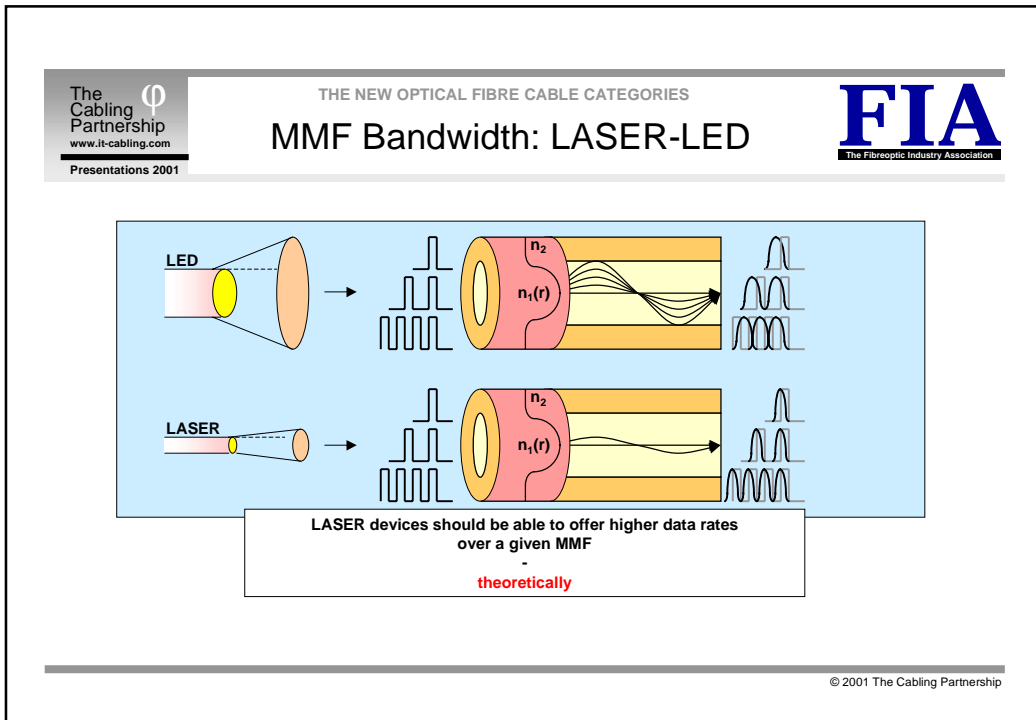
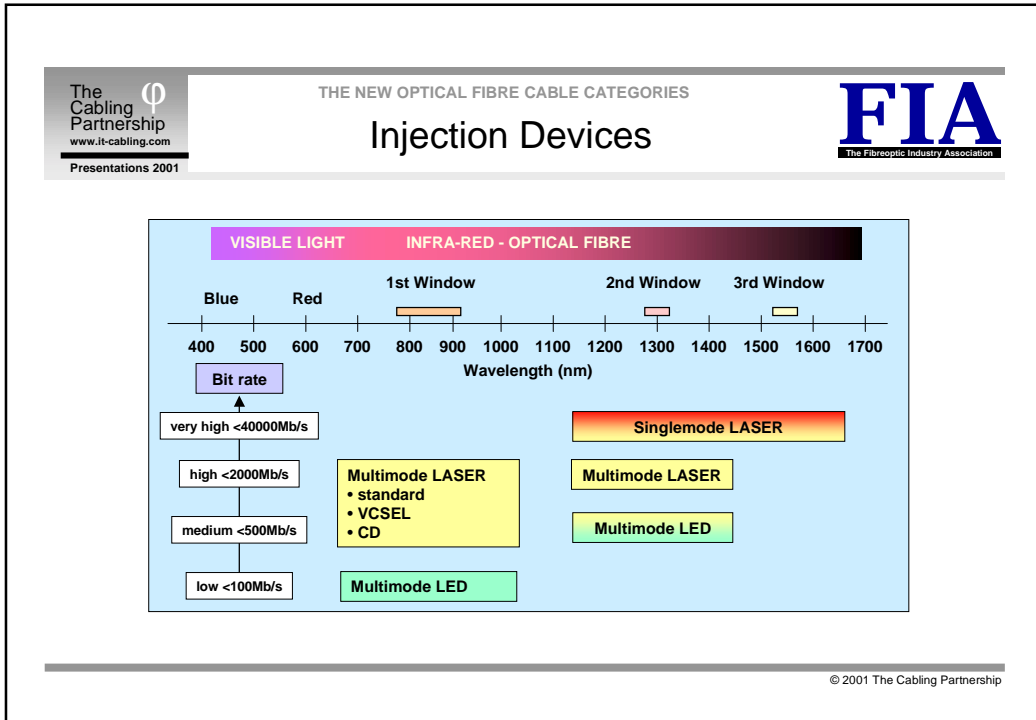
Geometry

d/D	NA
8-10/125	0.10

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FIA LAN ASG

Future FIA publications


End

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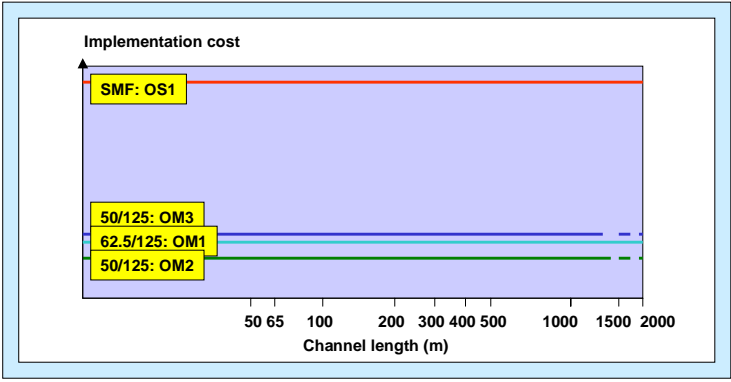
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100Mb/s Implementation



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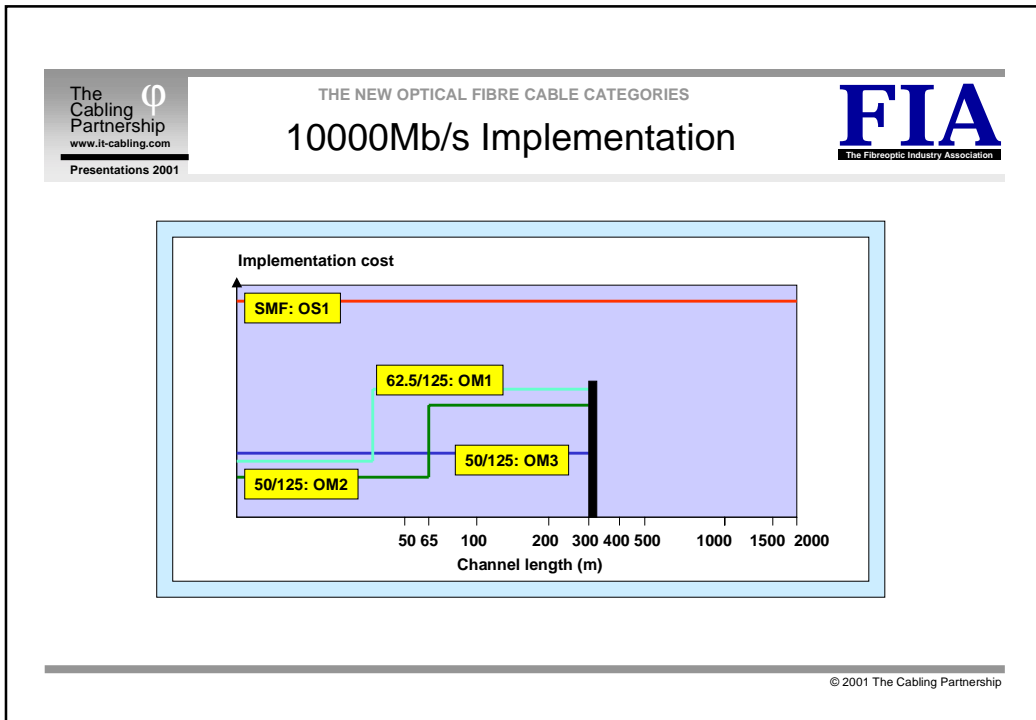
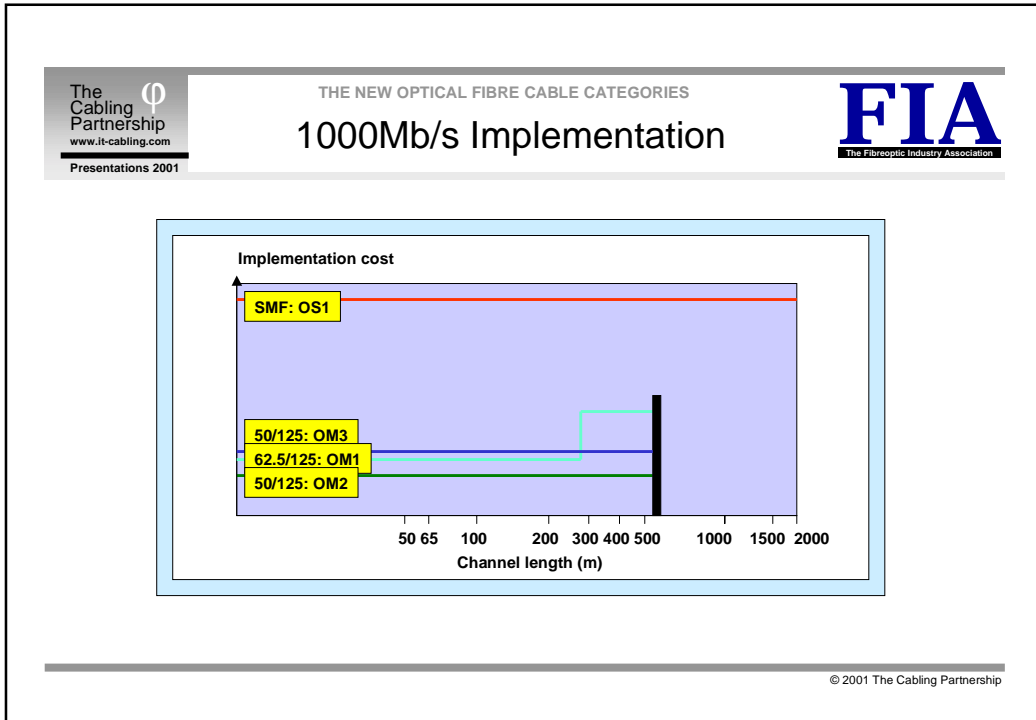


The chart displays implementation cost on the y-axis and channel length in meters on the x-axis (logarithmic scale: 50, 65, 100, 200, 300, 400, 500, 1000, 1500, 2000). Four data series are shown: SMF: OS1 (highest cost, constant), 50/125: OM3 (medium cost, constant), 62.5/125: OM1 (lower cost, constant), and 50/125: OM2 (lowest cost, constant).

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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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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	

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WWDM

Data rate $D = 4 \times (D/4)$

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OF LAN Applications



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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

SIGNAL CLARITY

Attenuation
Dispersion

PROTOCOL FUNCTION

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

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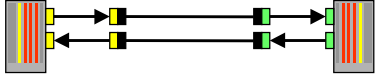
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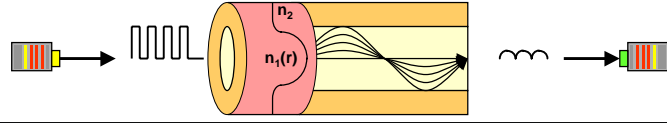
MMF Systems



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System operation requires that the signal is both large enough and clear enough to be interpreted at the receiver



Launched power - receiver sensitivity defines maximum allowed attenuation	Maximum channel length defined by <ul style="list-style-type: none"> • cable attenuation • number of connections • delay limits 	If available bandwidth is irrelevant	Attenuation (A) - Limited systems
		If available bandwidth is relevant	Bandwidth (B) - Limited systems


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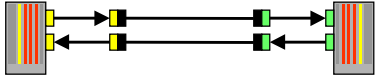
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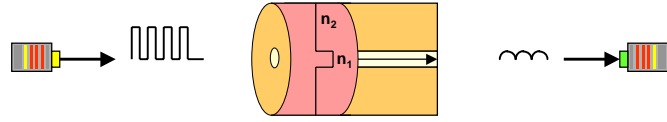
SMF Systems



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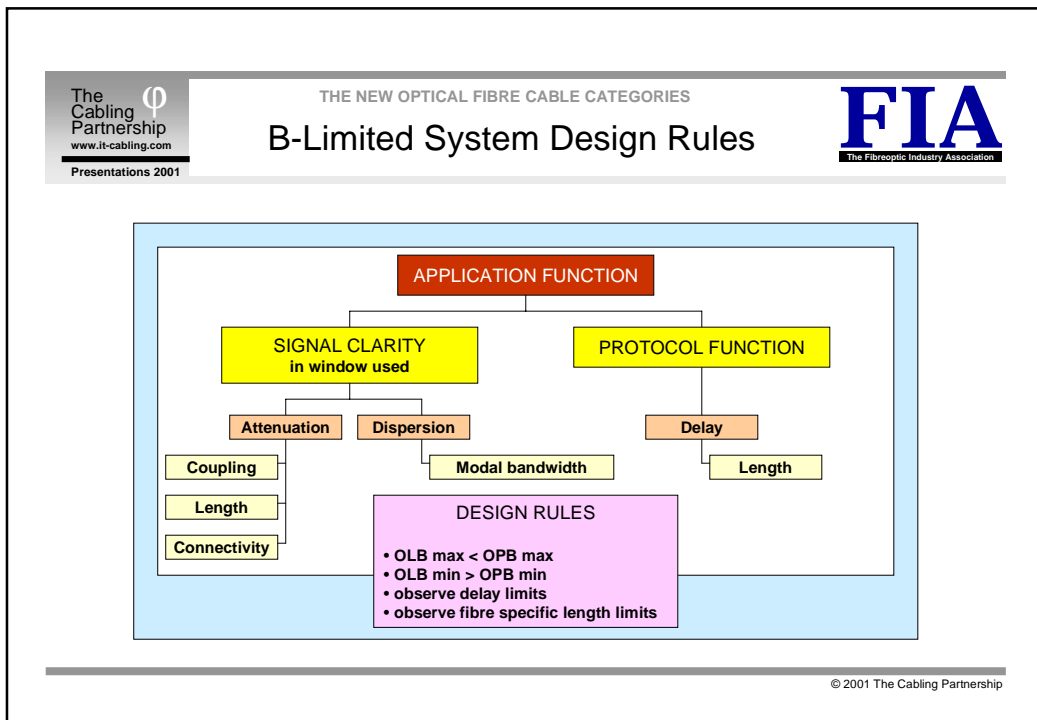
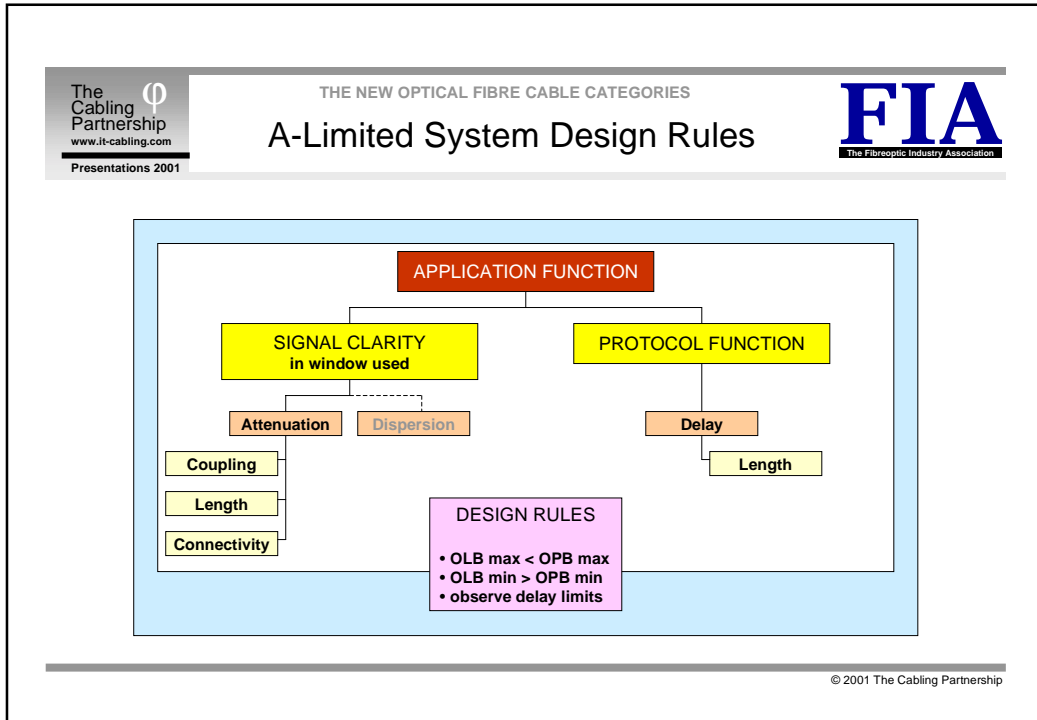


Launched power - receiver sensitivity defines maximum allowed attenuation	Maximum channel length defined by <ul style="list-style-type: none"> • cable attenuation • number of connections • delay limits 	If total dispersion is irrelevant	Attenuation (A) - Limited systems
		If total dispersion is relevant	Dispersion (D) - Limited systems

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A-Limited MMF LAN standards




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		50/125 (OMx)		62.5/125 (OMx)		
		Max. length (m)	OPB max. (dB)	Max. length (m)	OPB max. (dB)	OPB Δ (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


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B-limited LAN standards



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		50/125 (OM2) 500/500MHz.km		62.5/125 (OM1) 200/500MHz.km		
		Max. length (m)	OPB max. (dB)	Max. length (m)	OPB max. (dB)	OPB Δ (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

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A-Limited SMF LAN standards




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Limits defined in LAN standard

SMF (OS1)	
Max. length (m)	OPB max. (dB)
5000	4.56

1300 nm	IEEE 802.3: 1000BASE-LX: Gigabit Ethernet
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Unallocated margin and OPB




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	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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Agenda



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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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Next steps



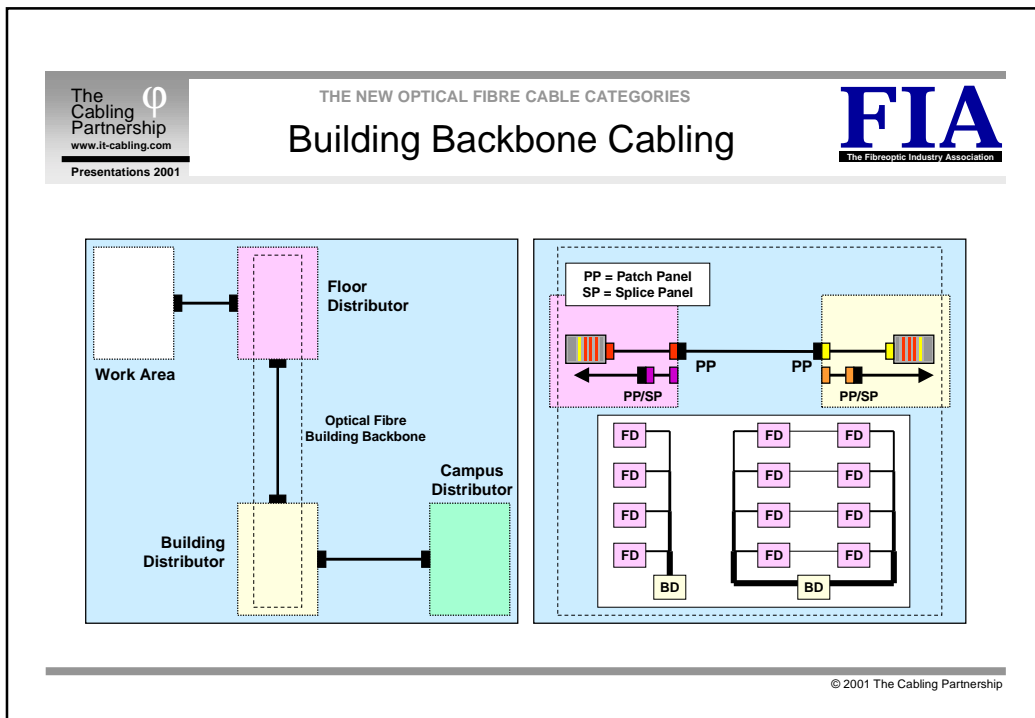
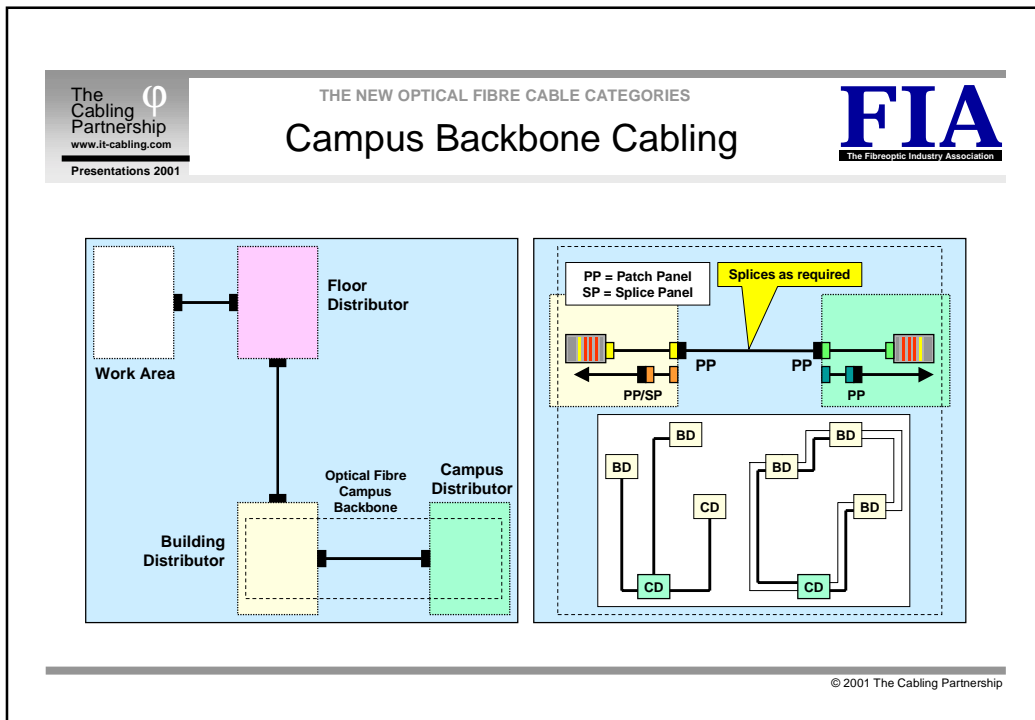
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2000 SERIES DOCUMENT SET	
DESIGN	OPTICAL FIBRE CABLING: LAN APPLICATION SUPPORT GUIDE OPTICAL FIBRE CABLING: WAN APPLICATION SUPPORT GUIDE
OPERATION	OPTICAL FIBRE CABLING: QUALITY ASSURANCE OPTICAL FIBRE CABLING: ADMINISTRATION
INSTALLATION	OPTICAL 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

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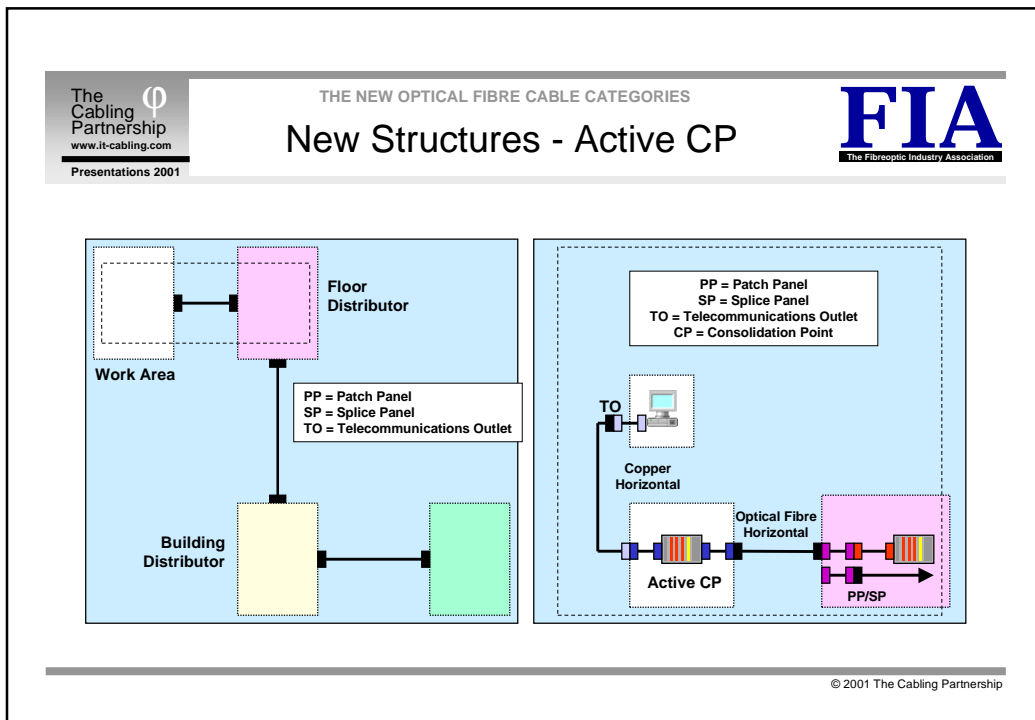
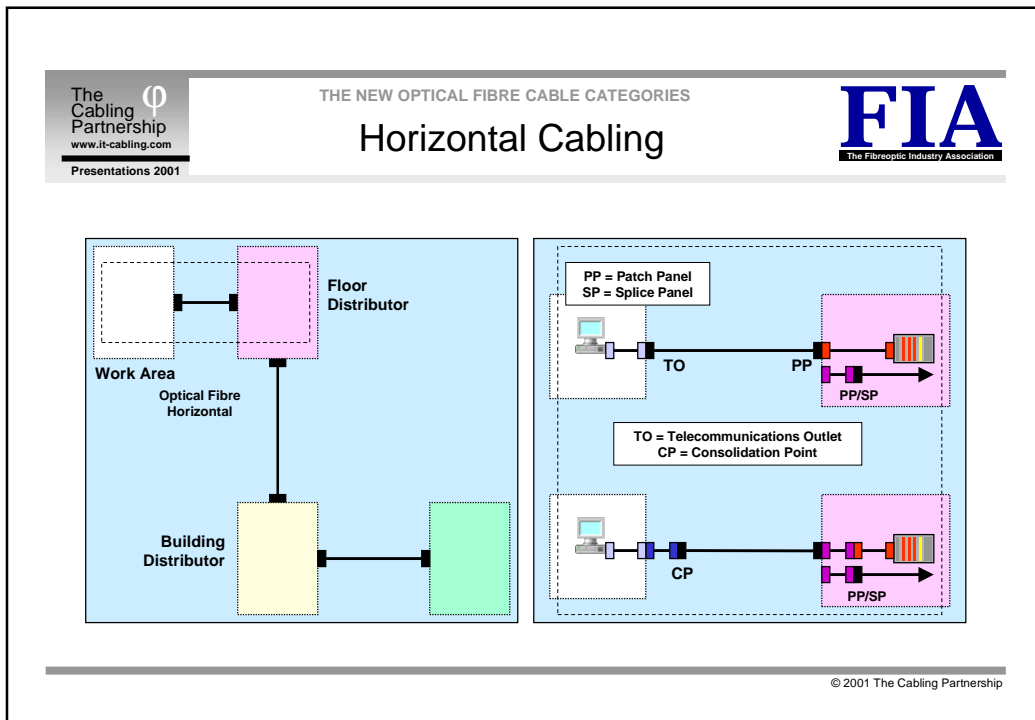
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