



# DATA CABLING - STILL IN THE MELTING POT?

prepared and delivered

by



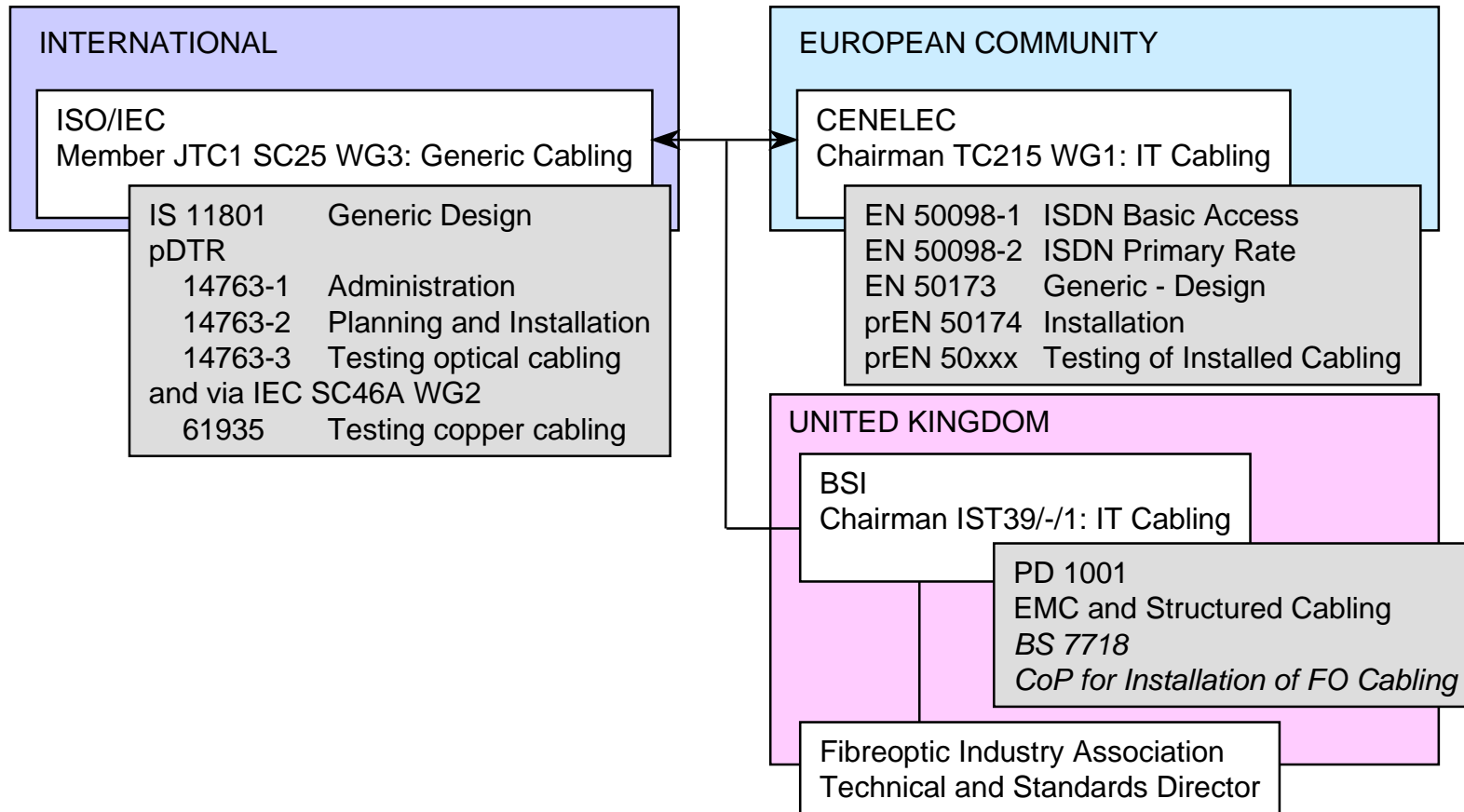
BSI,  
Chiswick, London  
21st July 1998

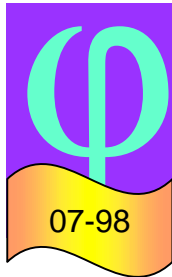
The Cabling Partnership  
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# Mike Gilmore

Senior Partner, The Cabling Partnership





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# Cabling Design Standards

INTERNATIONAL  
IS 11801 (1995)  
Information Technology  
Generic Cabling for Customer Premises

Amendment 1998  
Revision 2001?

EUROPEAN  
EN 50173 (1995)  
Information Technology  
Generic Cabling Systems

Amendment 1998  
Revision 2000

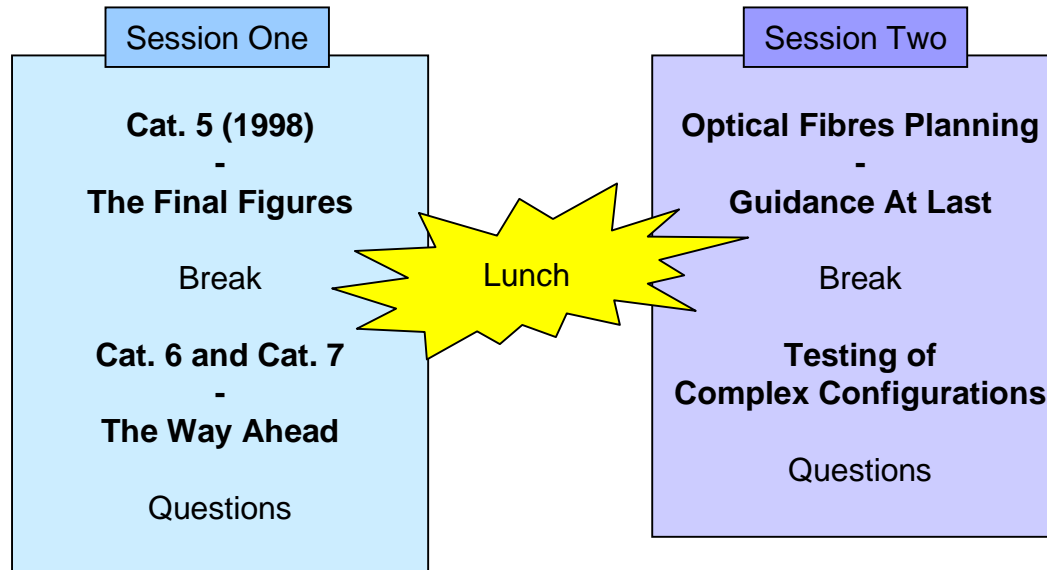
UNITED STATES  
ANSI/TIA/EIA 568A  
Commercial Building  
Telecommunications Cabling Standard

Continuous amendment  
Revision ANSI/TIA/EIA 568B (200?)



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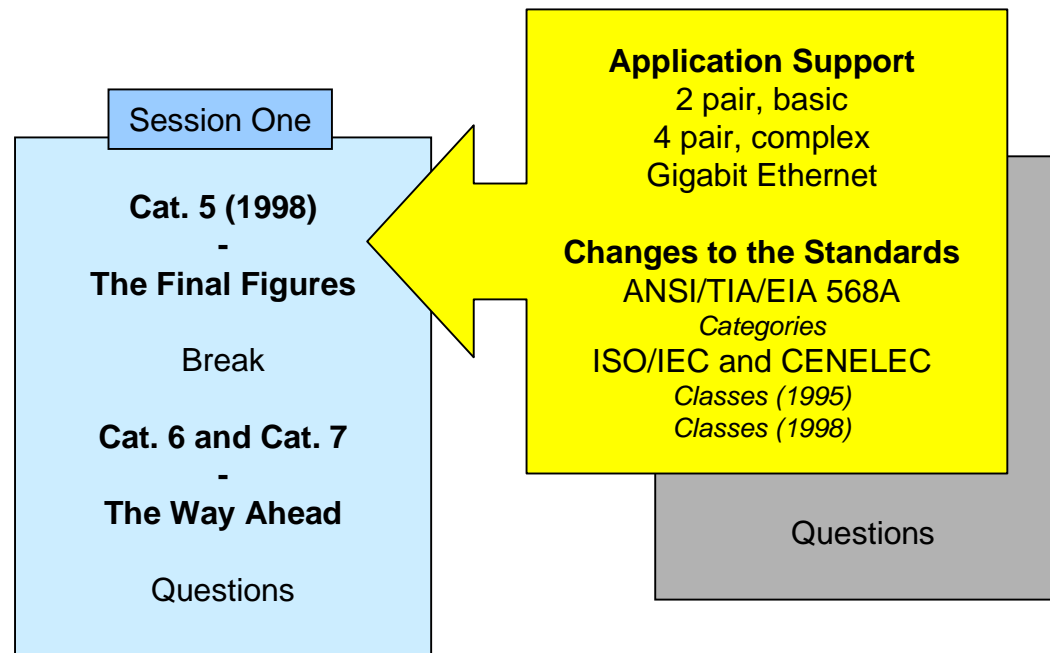
# Agenda





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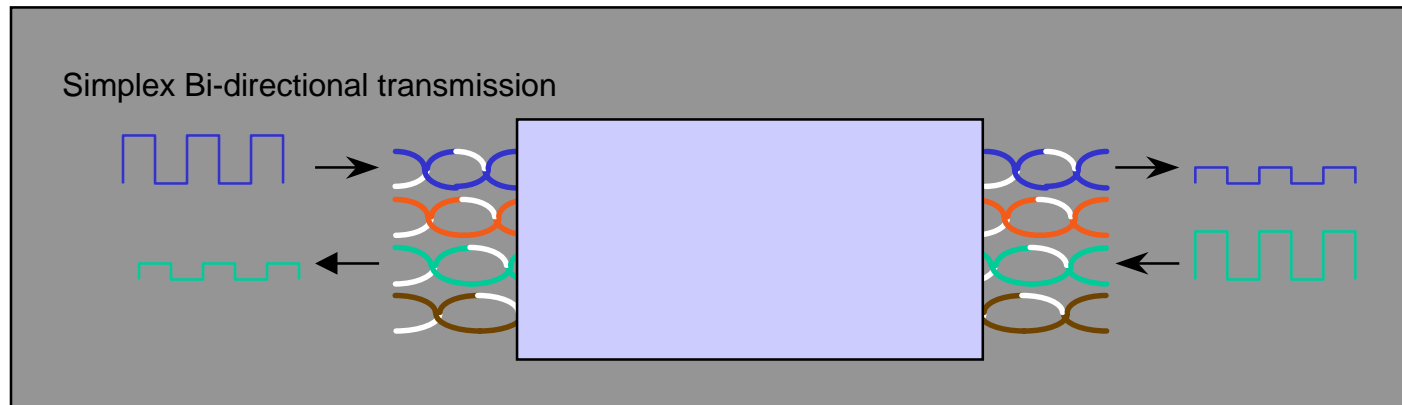
# Agenda





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# 2 Pair, Basic Applications

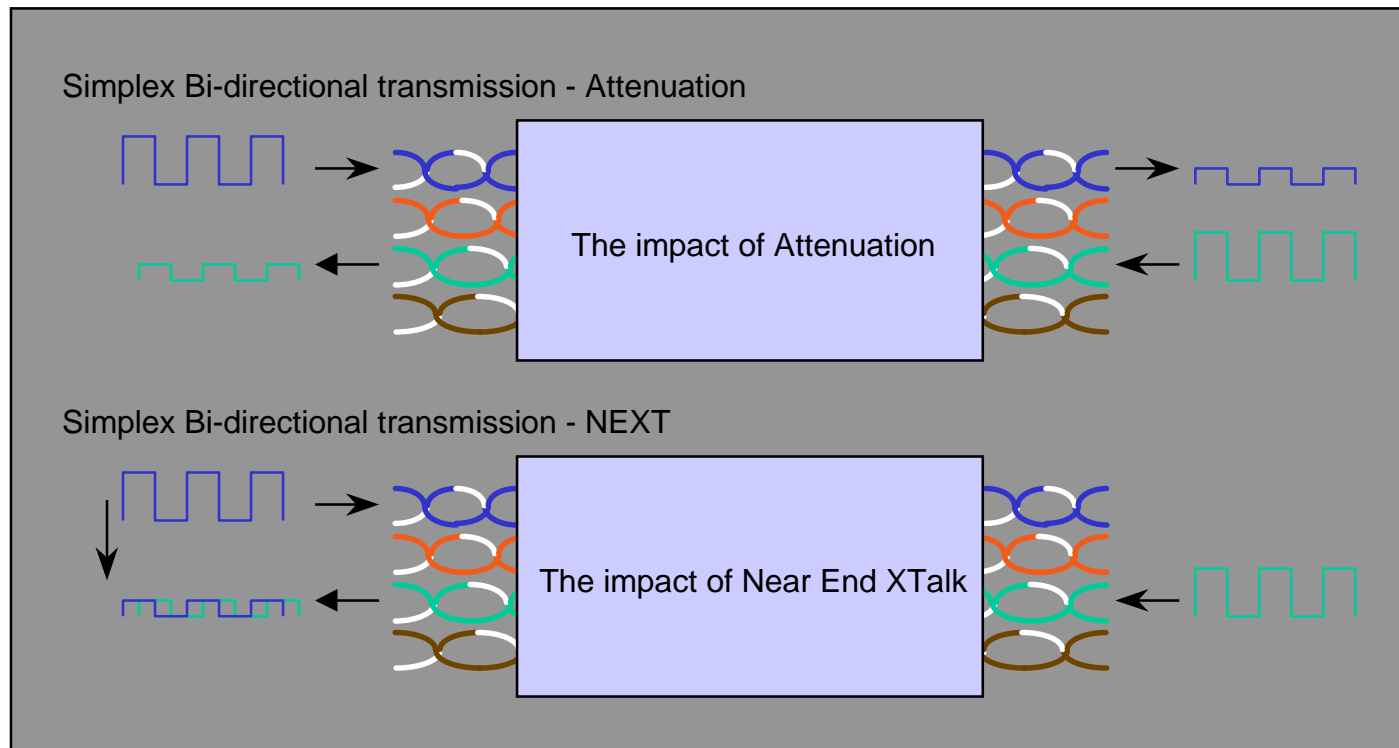


NOTE: transmissions over balanced pairs are not of square wave format



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# Attenuation and NEXT

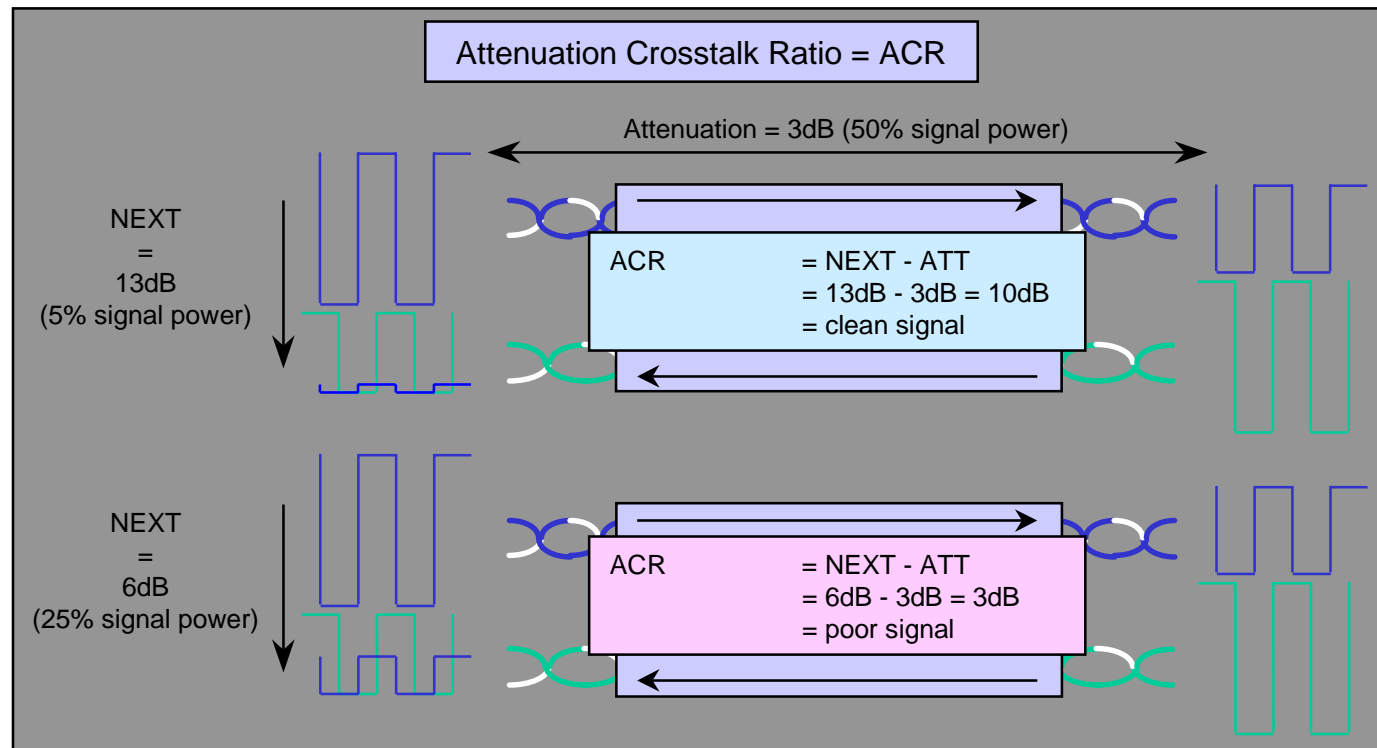


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# Attenuation Crosstalk Ratio

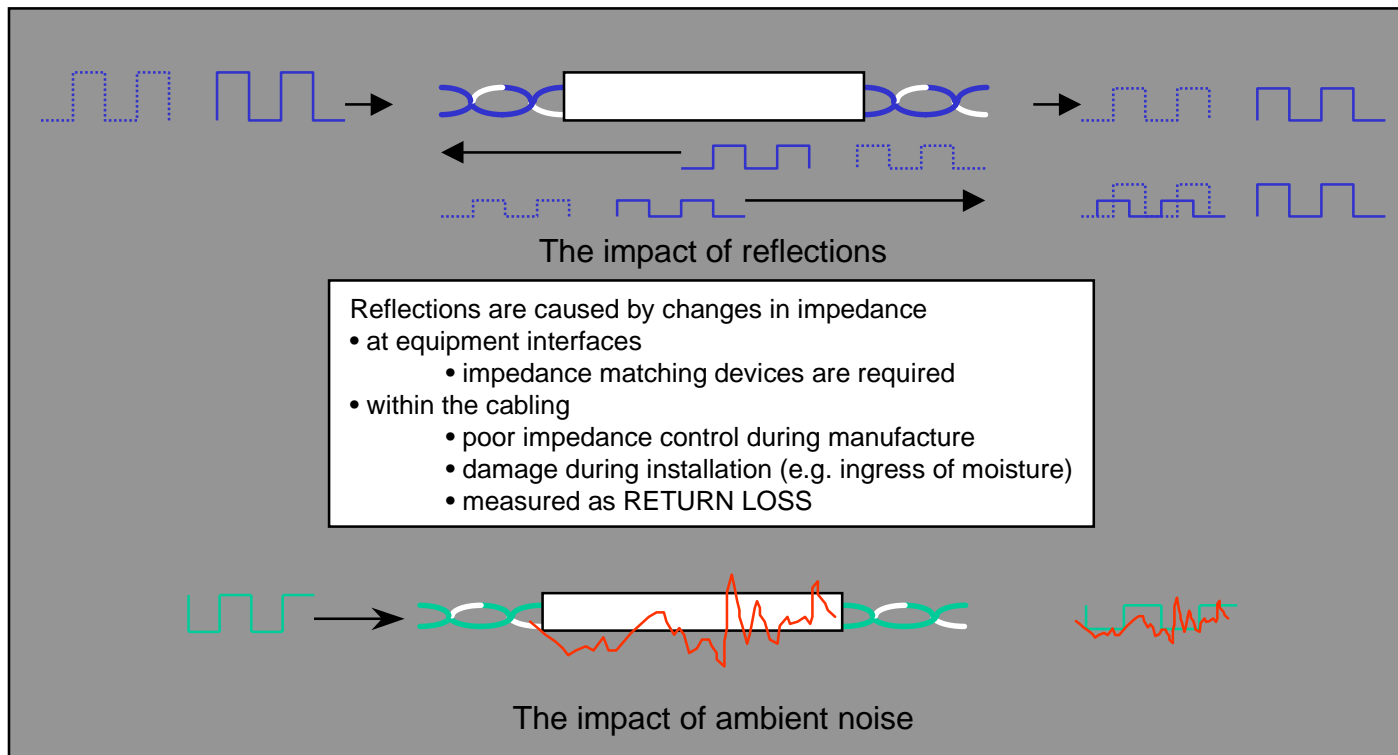


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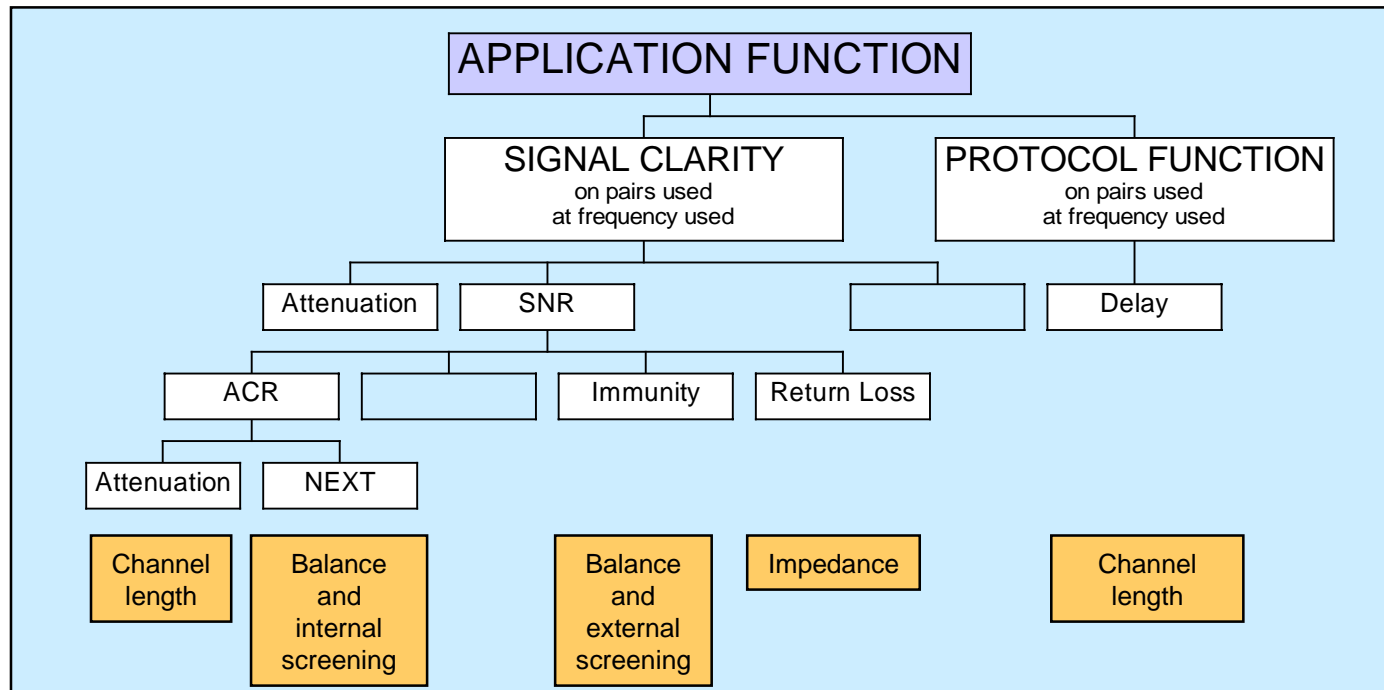
# Additional Noise Sources





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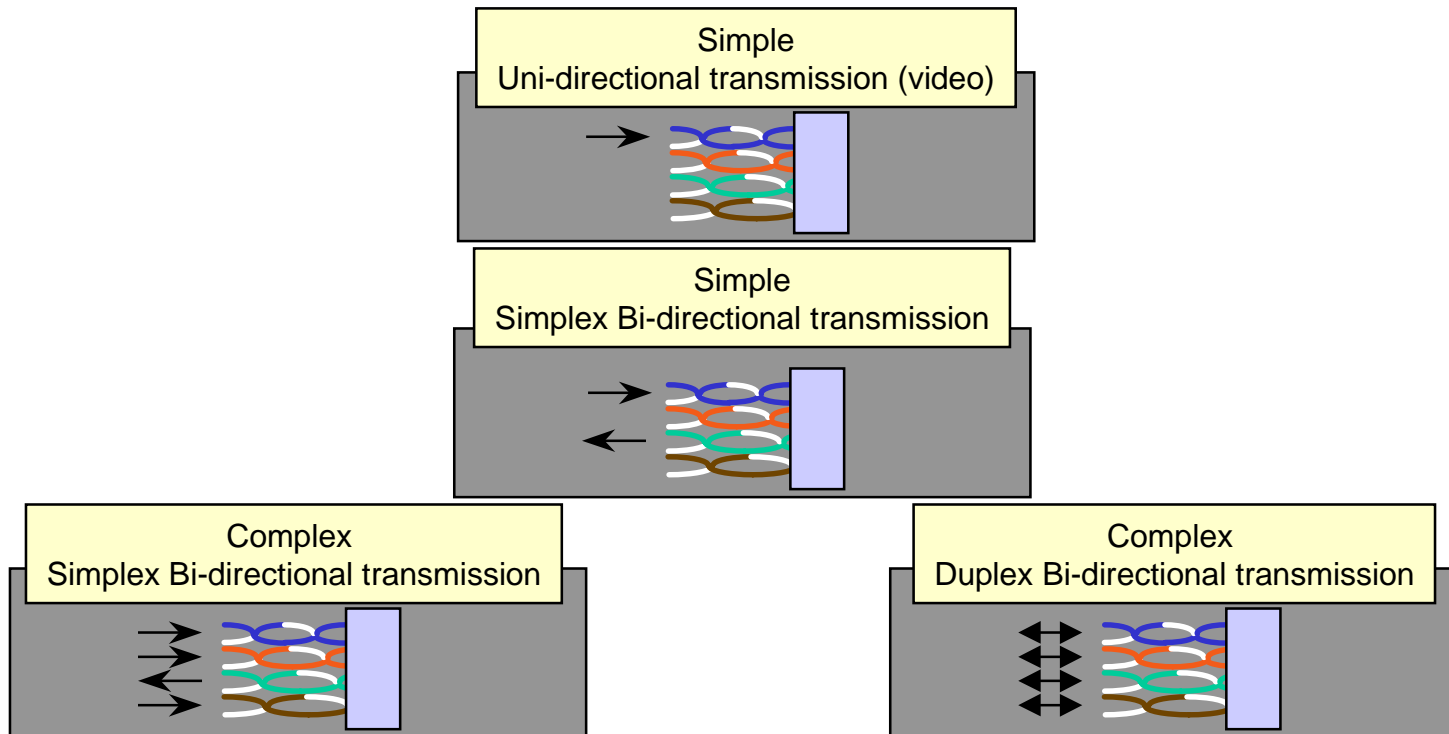
# Basic Application Support





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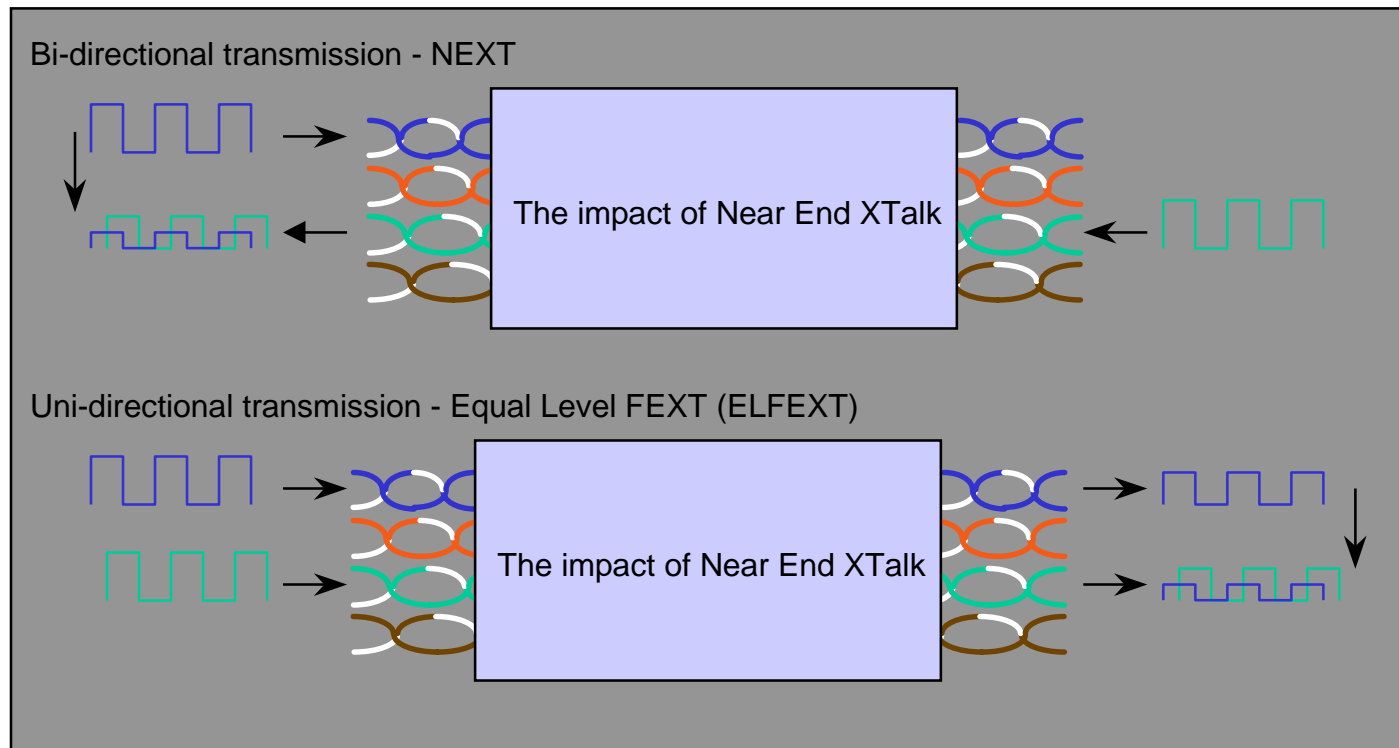
# Transmission Options





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# The Impact of Crosstalk - I

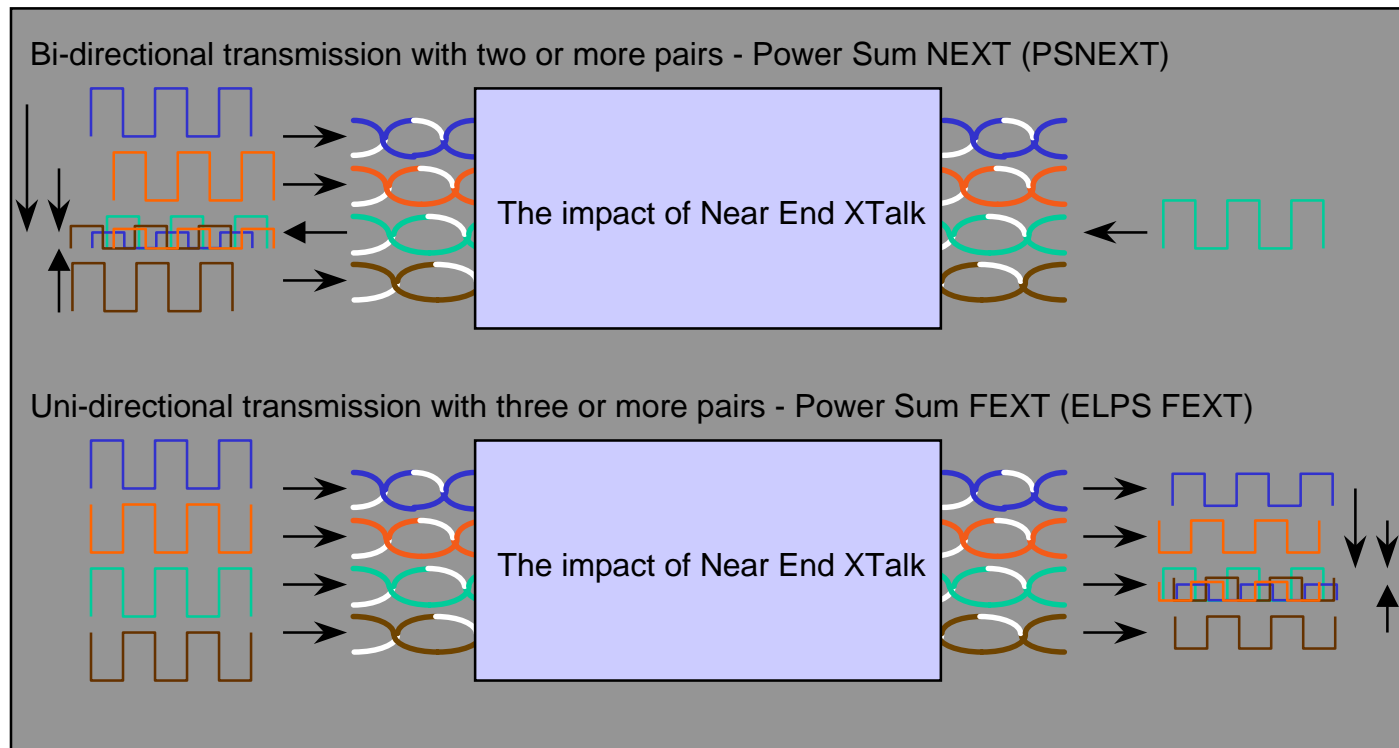


NOTE: transmissions over balanced pairs are not of square wave format



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# The Impact of Crosstalk - II



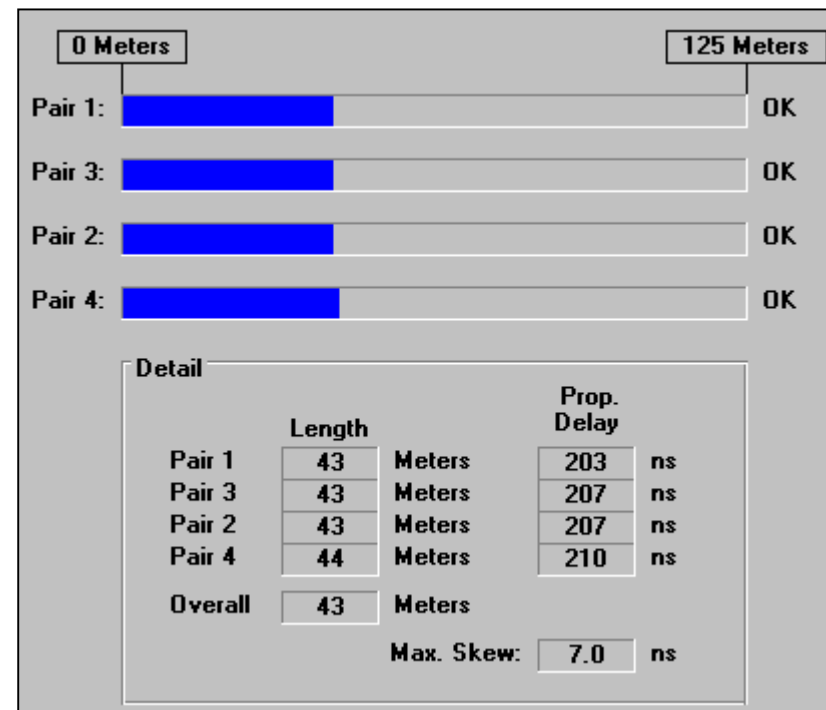
NOTE: transmissions over balanced pairs are not of square wave format



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# NVP, Delay and Skew

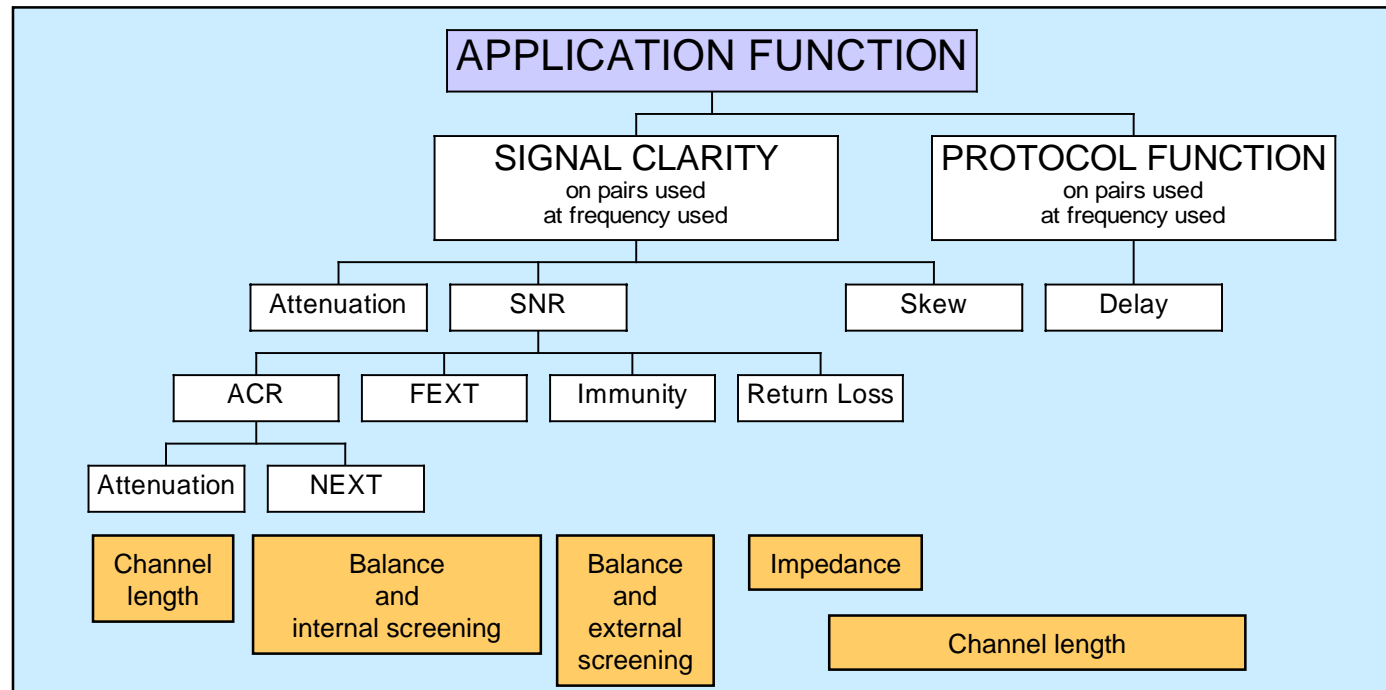
- NVP
  - nominal velocity of propagation
    - % of speed of light
- delay (uni- or bi-directional)
  - pairs lengths differ
    - due to twist lay length
  - all pairs longer than cable
    - due to overall lay
- skew
  - the difference in delay
    - fastest pair - slowest pair





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# Complex Application Support





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# 1000BASE-T - A Challenge

- Gigabit Ethernet
  - duplex transmission
  - all four pairs
  - 250Mb/s per pair
    - in each direction
    - at the same time
- intended to operate over Category 5 channels
  - “best quality”
  - interconnect model preferred
  - additional requirements over Cat. 5 installed testing
    - skew
    - PSNEXT
    - ELFEXT, PSELFEXT
    - return loss



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# Changes to the Standards

ANSI/TIA/EIA 568A

Continuous amendment

### **Addendum 1**

PSNEXT requirements for components and installed cabling

### **Addendum 2**

Return loss and PSELFEXT for installed cabling (2 connector model)

### **Addendum 3**

Cat. 5E parameters for components and installed cabling.  
3dB excess on noise parameters supports 4 connector model for Gigabit Ethernet

IS 11801 (1995) and EN 50173

Amendment 1998

### **Requirements for installed base**

No changes to component specifications (new component specification will exist for Europe will be referenced in revision of EN 50173)

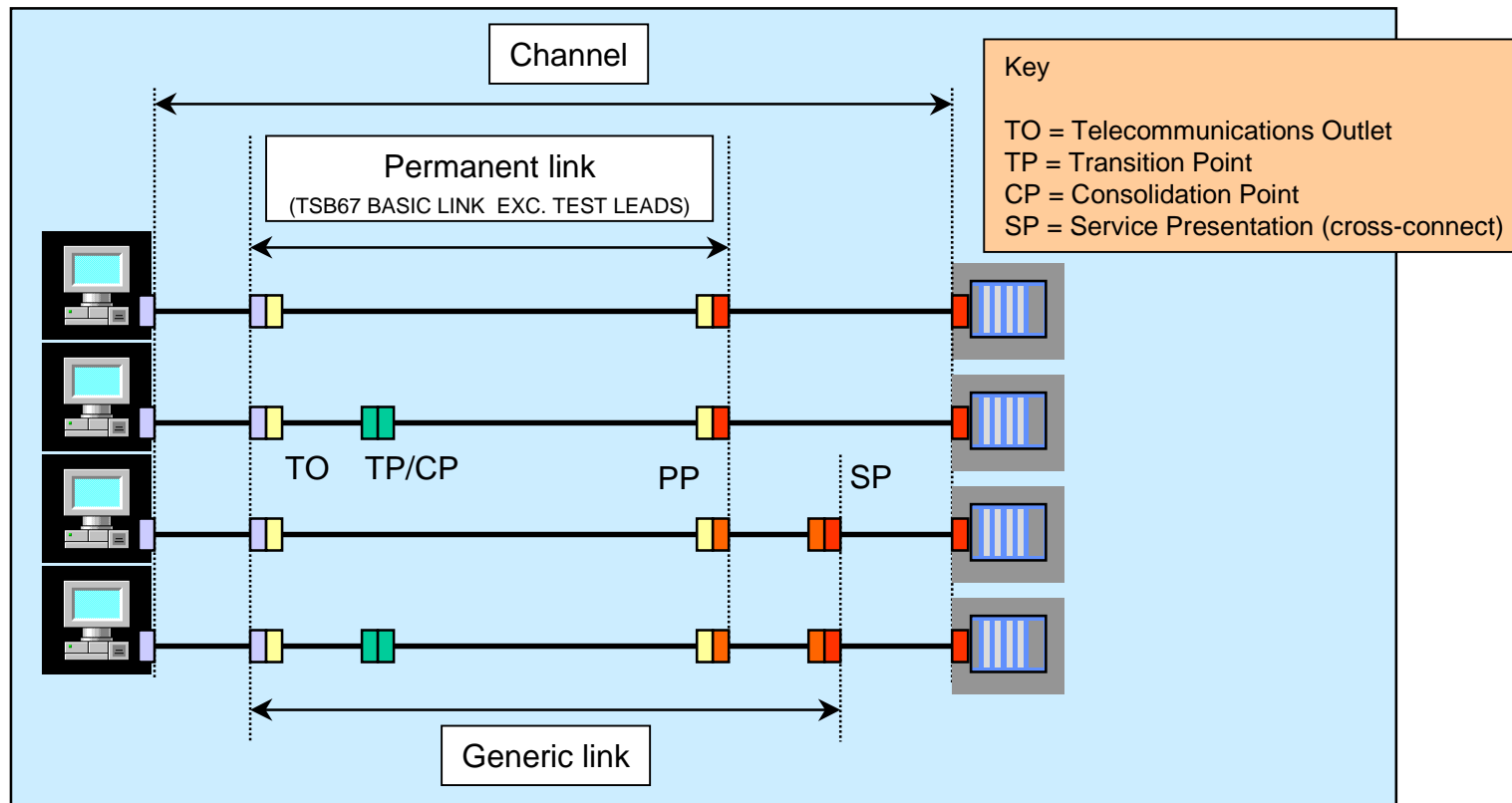
Complete parameter set included for links and channels

Supports 4 connector model for Gigabit Ethernet



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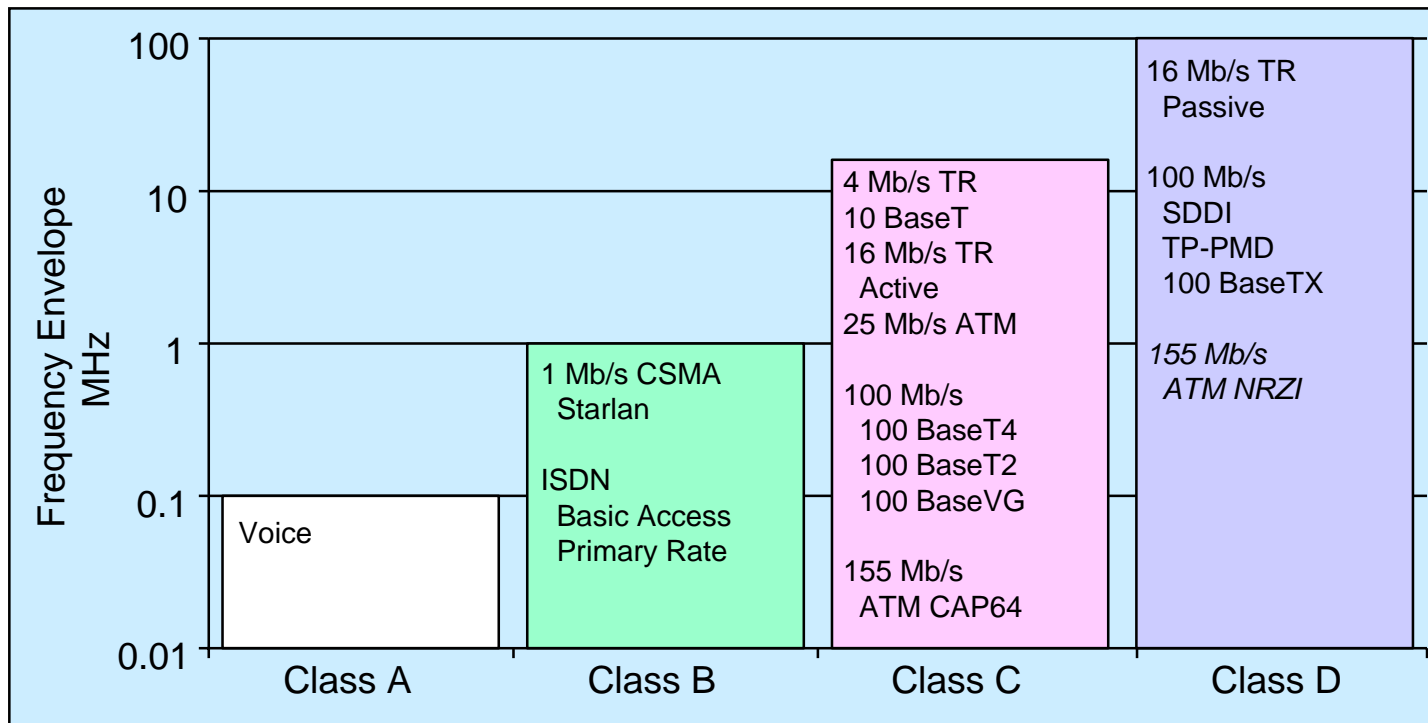
# Horizontal Links and Channel





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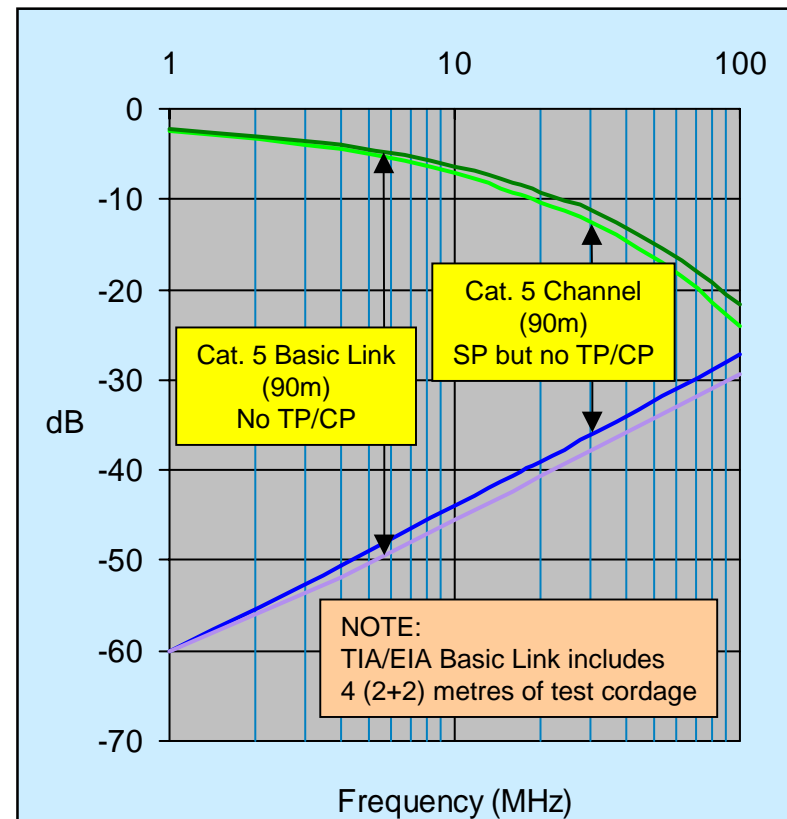
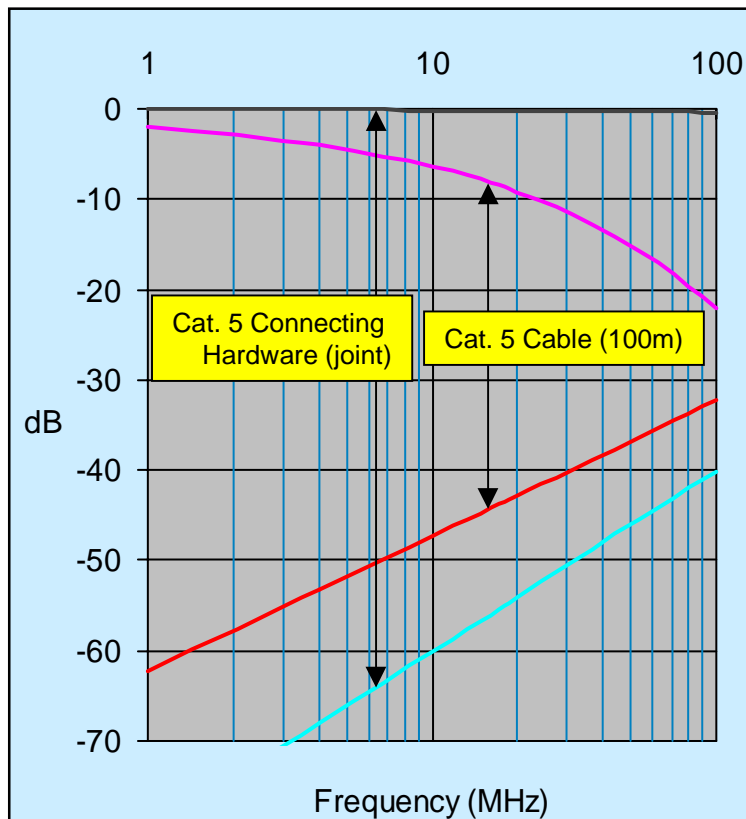
# ISO/CENELEC Classes





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# TIA Component Model (1995)





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# Installed Performance Limits

## CATEGORIES

ANSI/TIA/EIA 568A/TSB67

“Basic Link” performance specification

- based upon
  - component performance
  - 90 metre template
- three Categories
  - Category 3,4 and 5

## CLASSES (1995)

IS 11801/EN 50173

“Generic link” performance specification

- based upon application requirements
  - channel minus equipment cables
  - length independent
- four classes
  - A, B, C, D

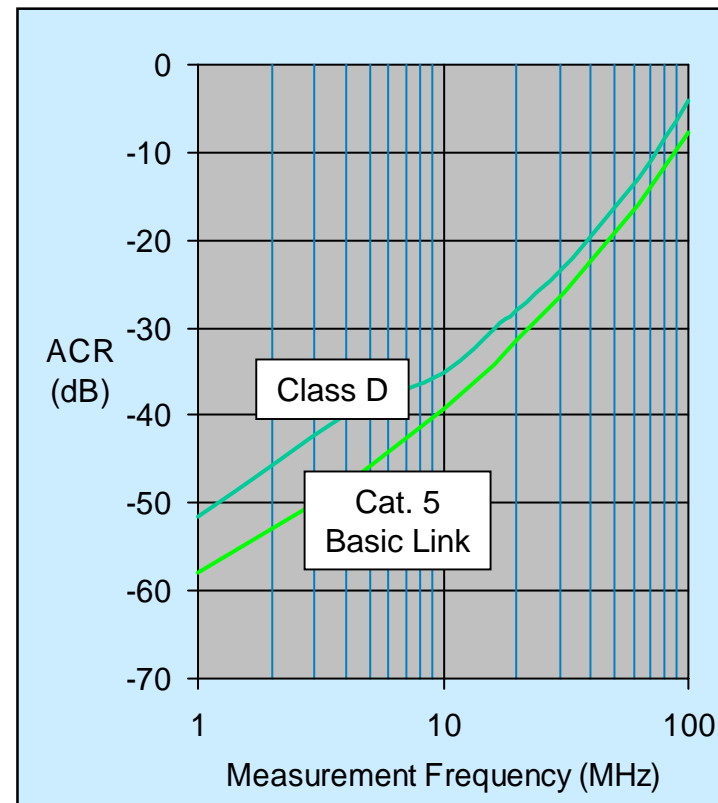
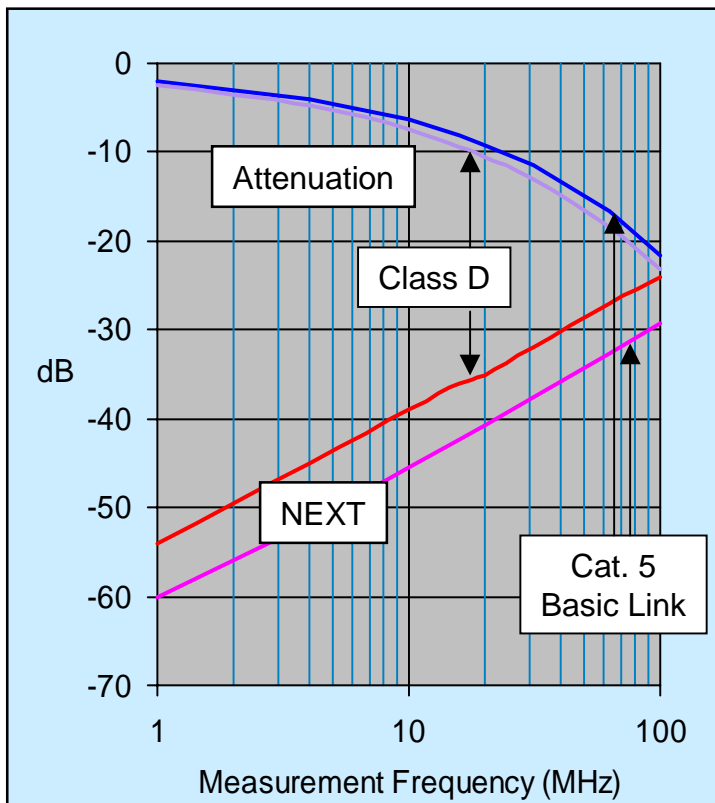
## **CATEGORY AND CLASS ARE NOT EQUIVALENT**

- intentionally
- Class was intended as a “safe limit” for applications
  - not a “testable” element
- Category 5 (1995) is the “safe limit” for cabling
  - installation base meeting TSB67 limits



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# Category and Class Limits





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# EN50173 (1998): Amndmt - I

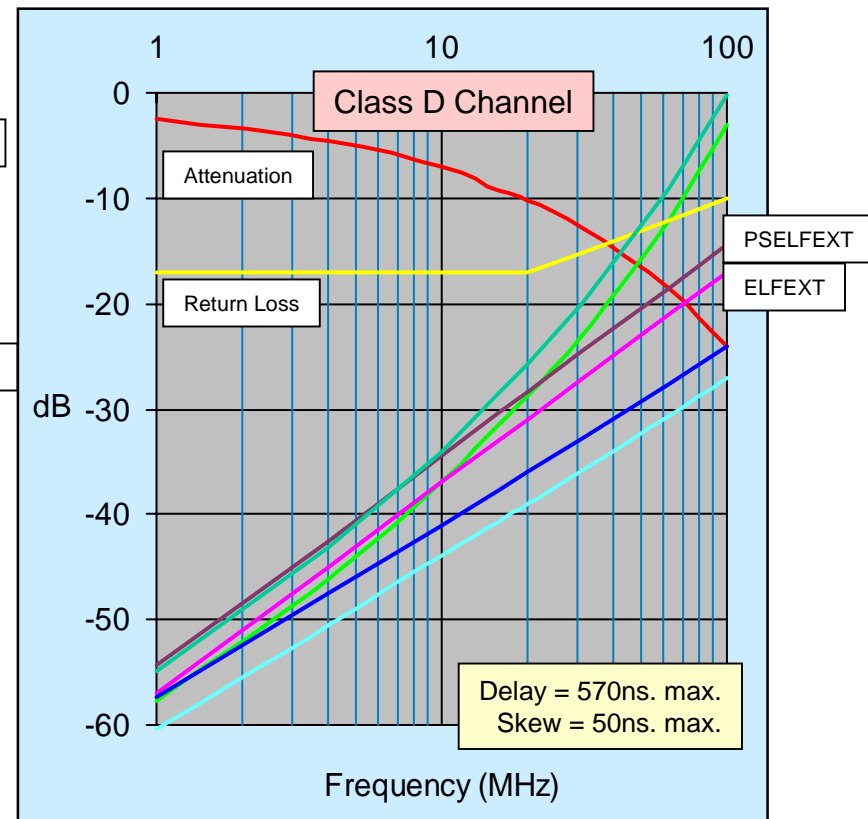
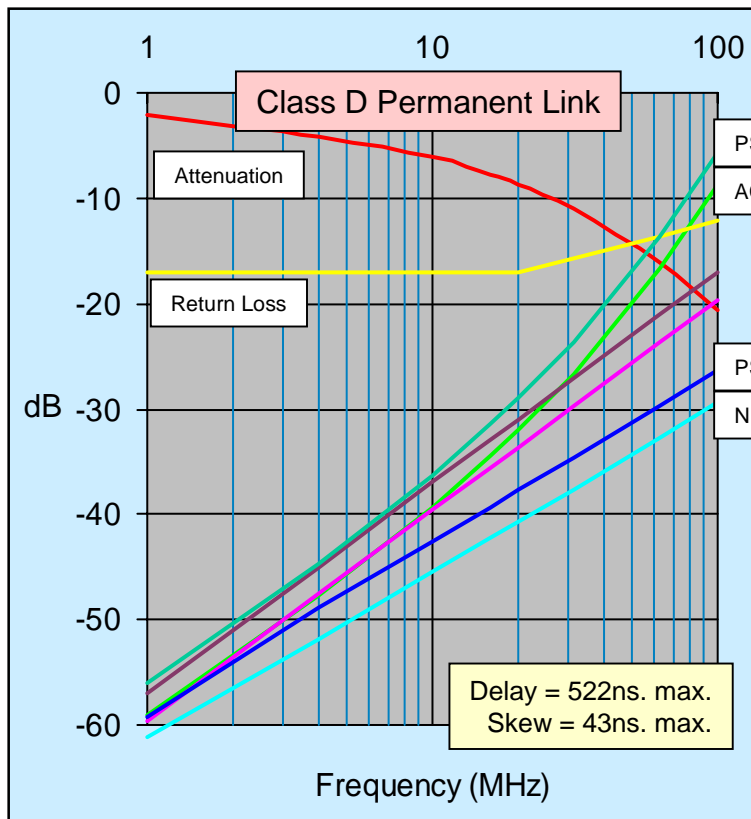
- “generic link” concept removed
- values specified for
  - channel
    - application performance
  - “permanent” link
    - 90 metres
    - mated connections
      - one at at each end

- Class concept retained
  - Class D
    - Category 5 implementation
  - Class C
    - Category 3 implementation
- extra parameters included
  - Return loss
  - PowerSum NEXT
  - ELFEXT
  - PowerSum ELFEXT
  - Delay/Skew



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# EN50173 (1998): Amndmt - II





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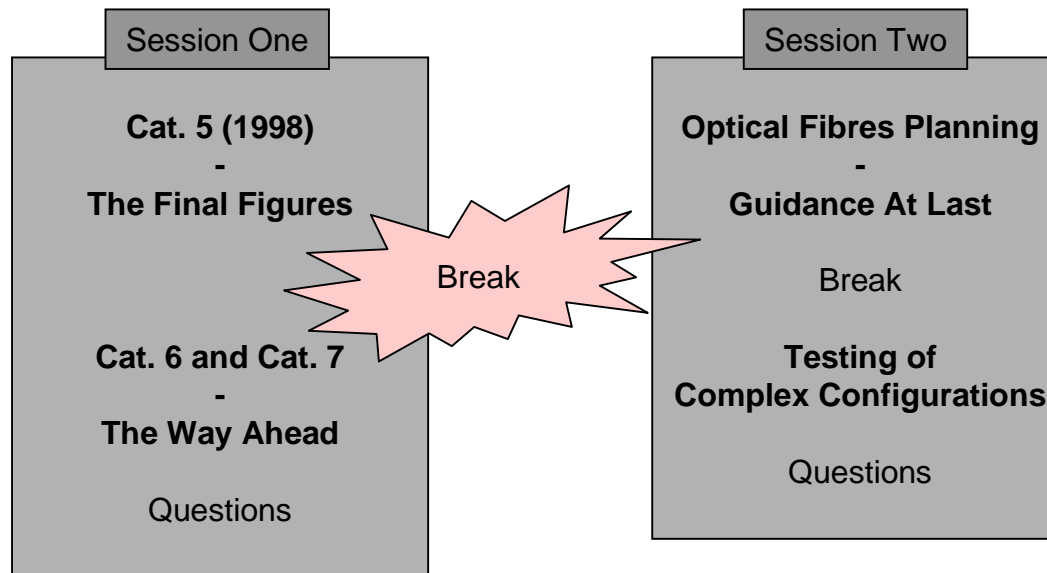
# Additional Information

- meeting PS requirements
  - cabling meets
    - PS NEXT requirements if measured worst NEXT is 1.8dB better than NEXT limit
    - PS ELFEXT requirements if measured worst FEXT is 2.2dB better than FEXT limit
- simple channels
  - need to meet “Permanent Link” requirements only
- differences remain
  - the US “Basic Link” includes the attenuation of the test cords
    - attenuation
    - ACR, PSACR
  - the ISO/CENELEC “Permanent Link” excludes the attenuation of the test cords
    - it is hoped that the US will adopt this position



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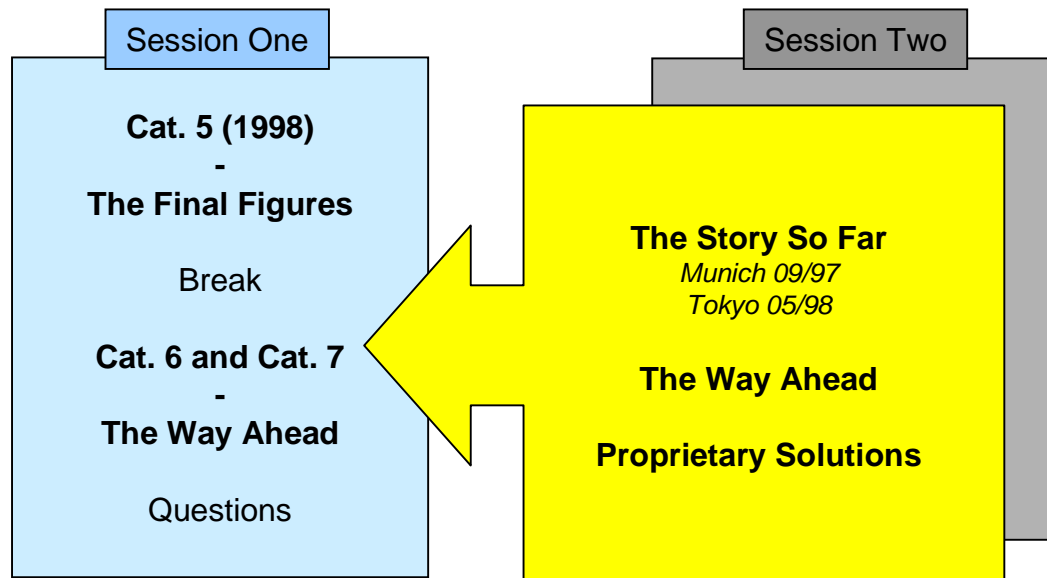
# Agenda





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# Agenda





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# The Munich Agreement

- Class E - Category 6
  - positive PSACR at 200MHz
  - supported over
    - unscreened balanced pairs
    - foil screened balanced pairs
    - IEC 60603-7 connectivity

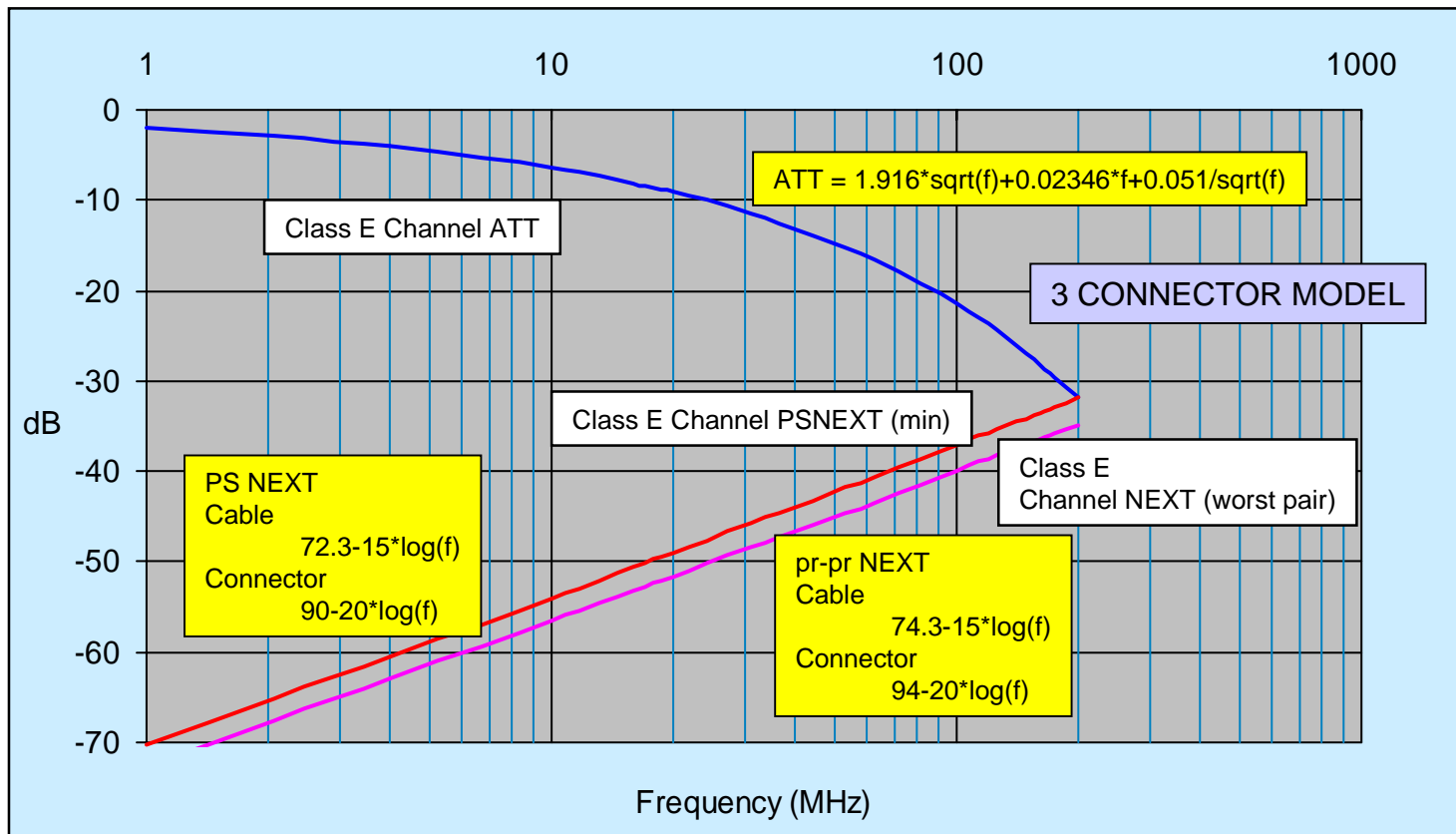
- Class F - Category 7
  - positive PSACR at 600MHz
  - supported over
    - individually screened balanced pairs
    - new connector

- backwards compatibility
  - lower Class applications
  - 4 pair solution



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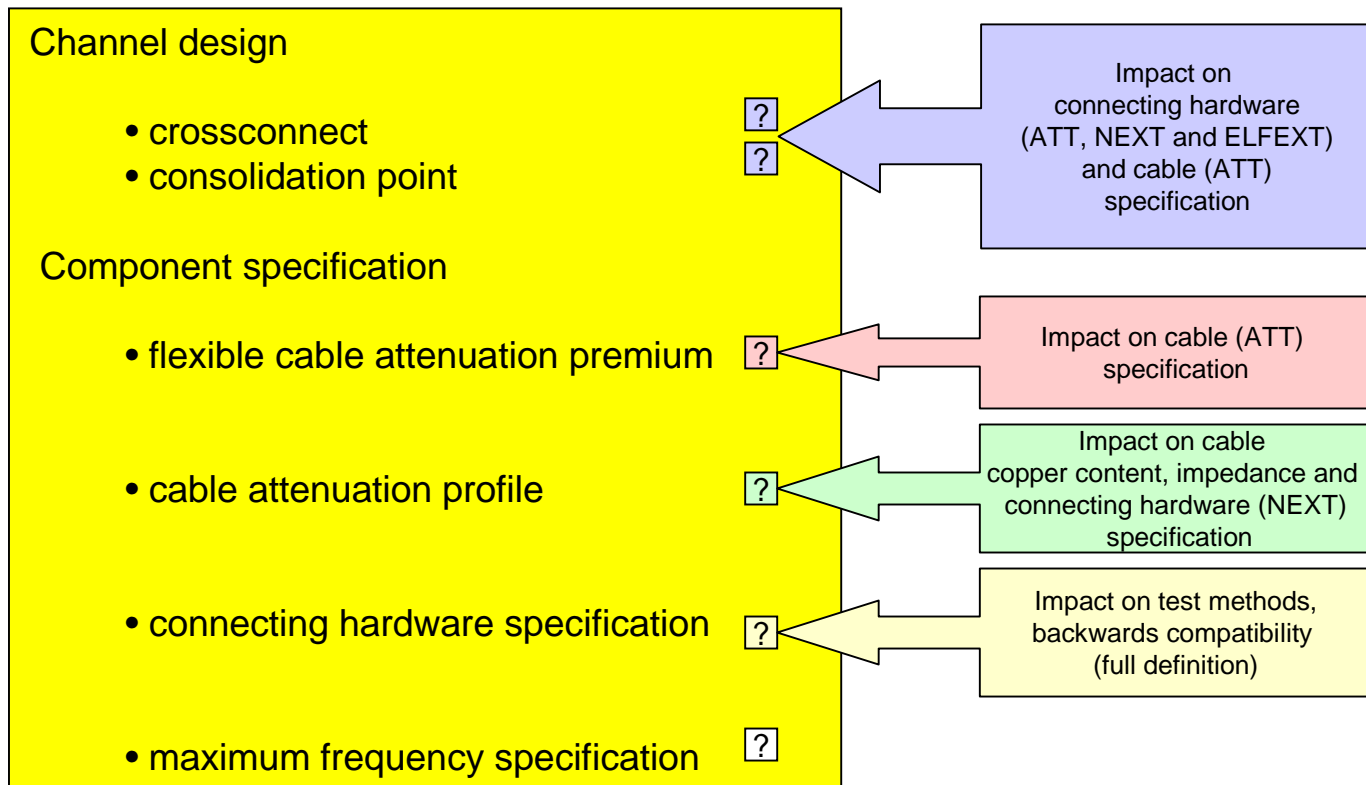
# “Class E” Channel (Munich)





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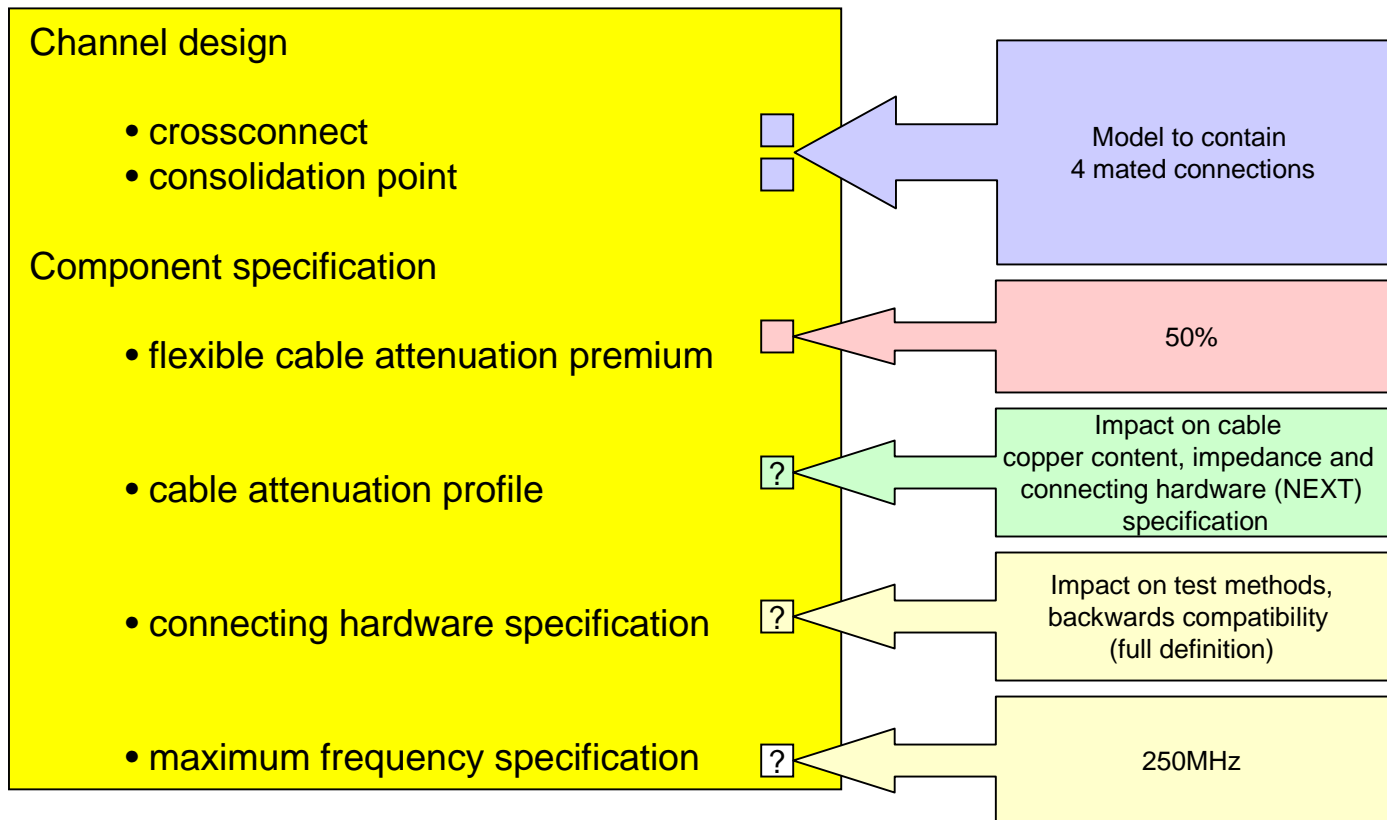
# Cat. 6 Action Items, 03/98





DATA CABLING - STILL IN THE MELTING POT?

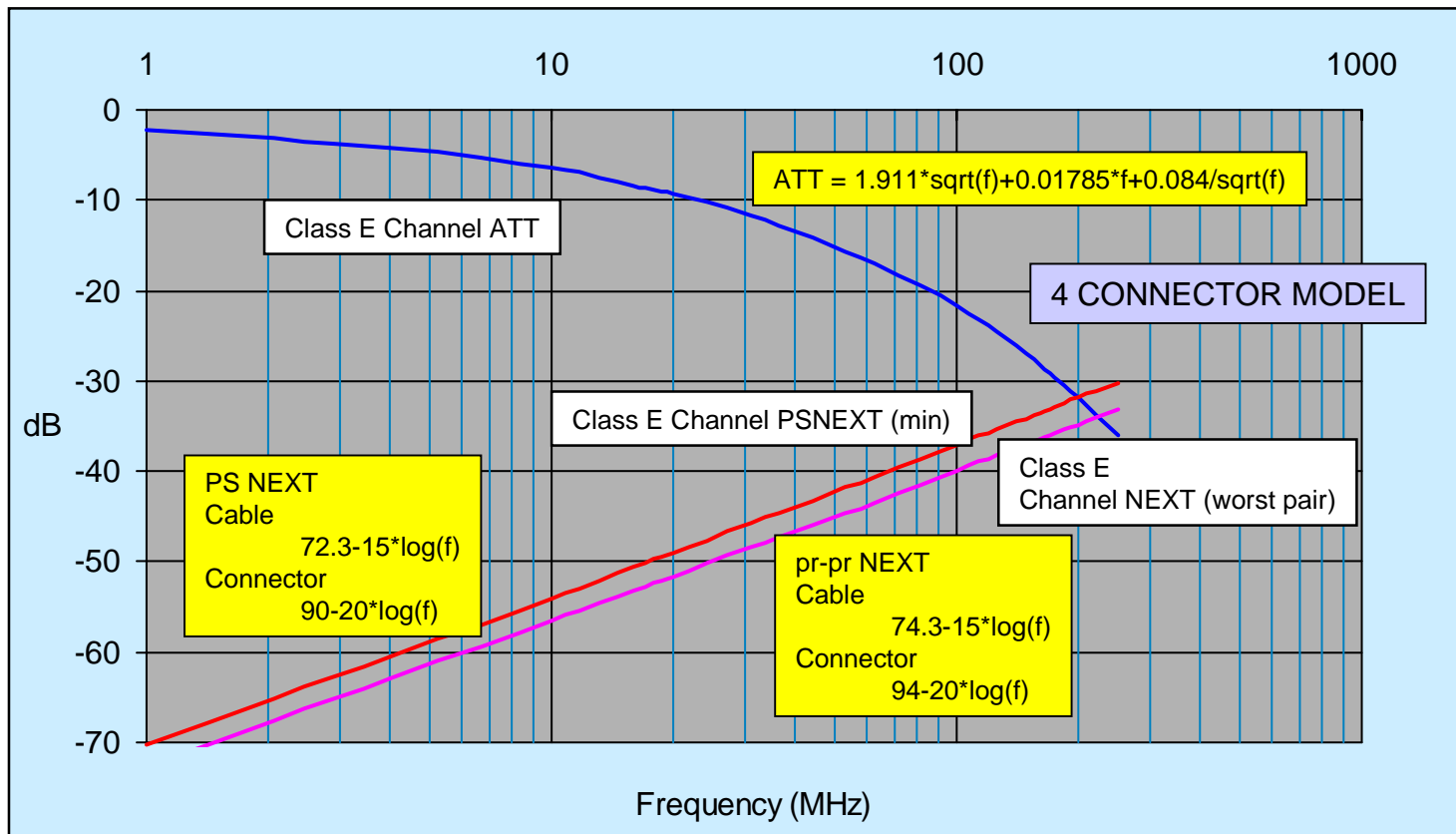
# Cat. 6 Status, Tokyo 05/98





DATA CABLING - STILL IN THE MELTING POT?

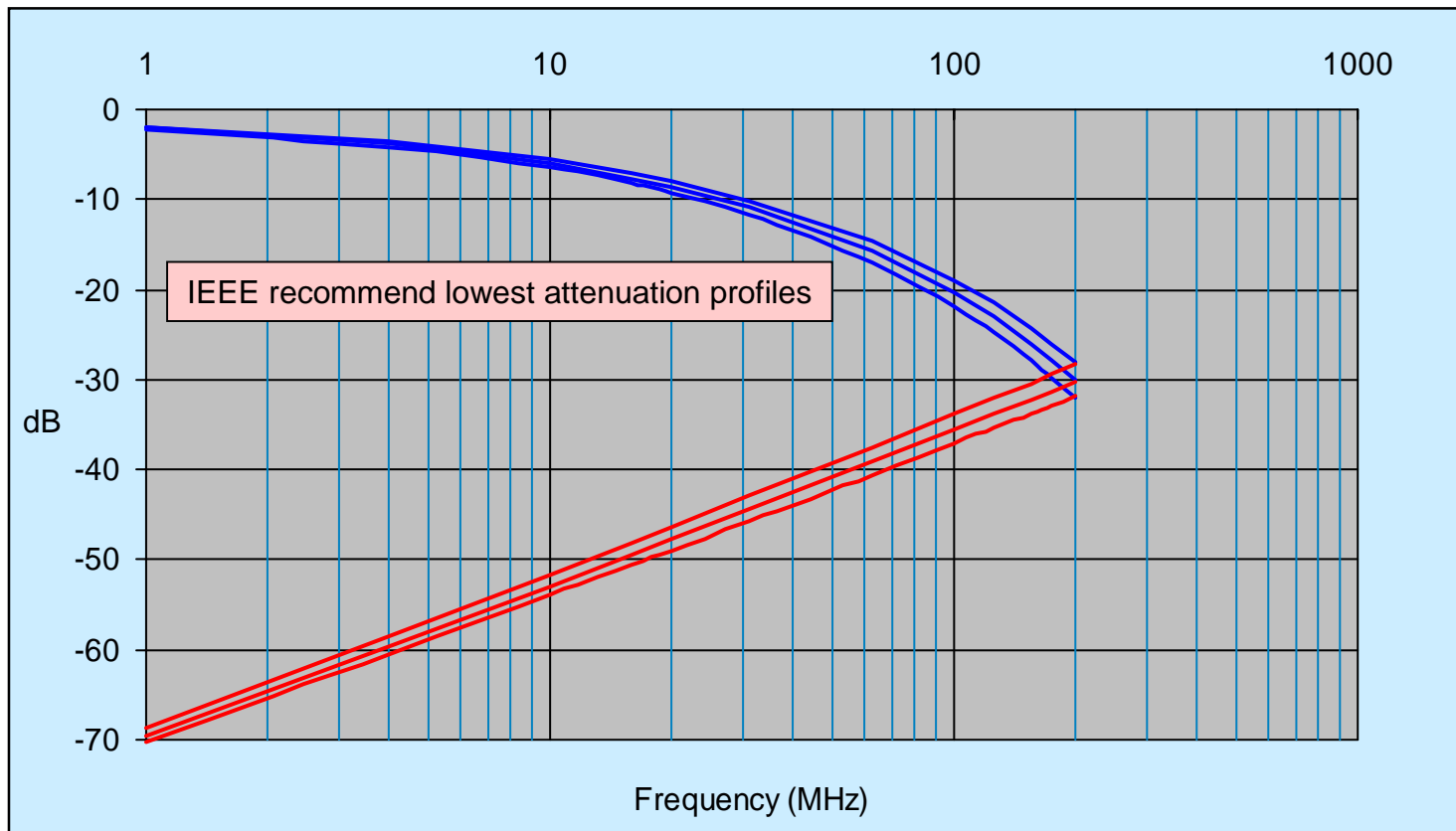
# “Class E” Channel (Tokyo)





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# Class E Alternatives





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# Cat. 6 Outstanding Issues

- connecting hardware
  - multi-vendor interoperability
    - Cat. 6 mix
  - backwards compatibility
    - Cat. 5 mix

Existing standards text from BS EN 50173 (1995)

„Links of a given class will support all applications of a lower link class.  
Link class A is regarded as the lowest class.“

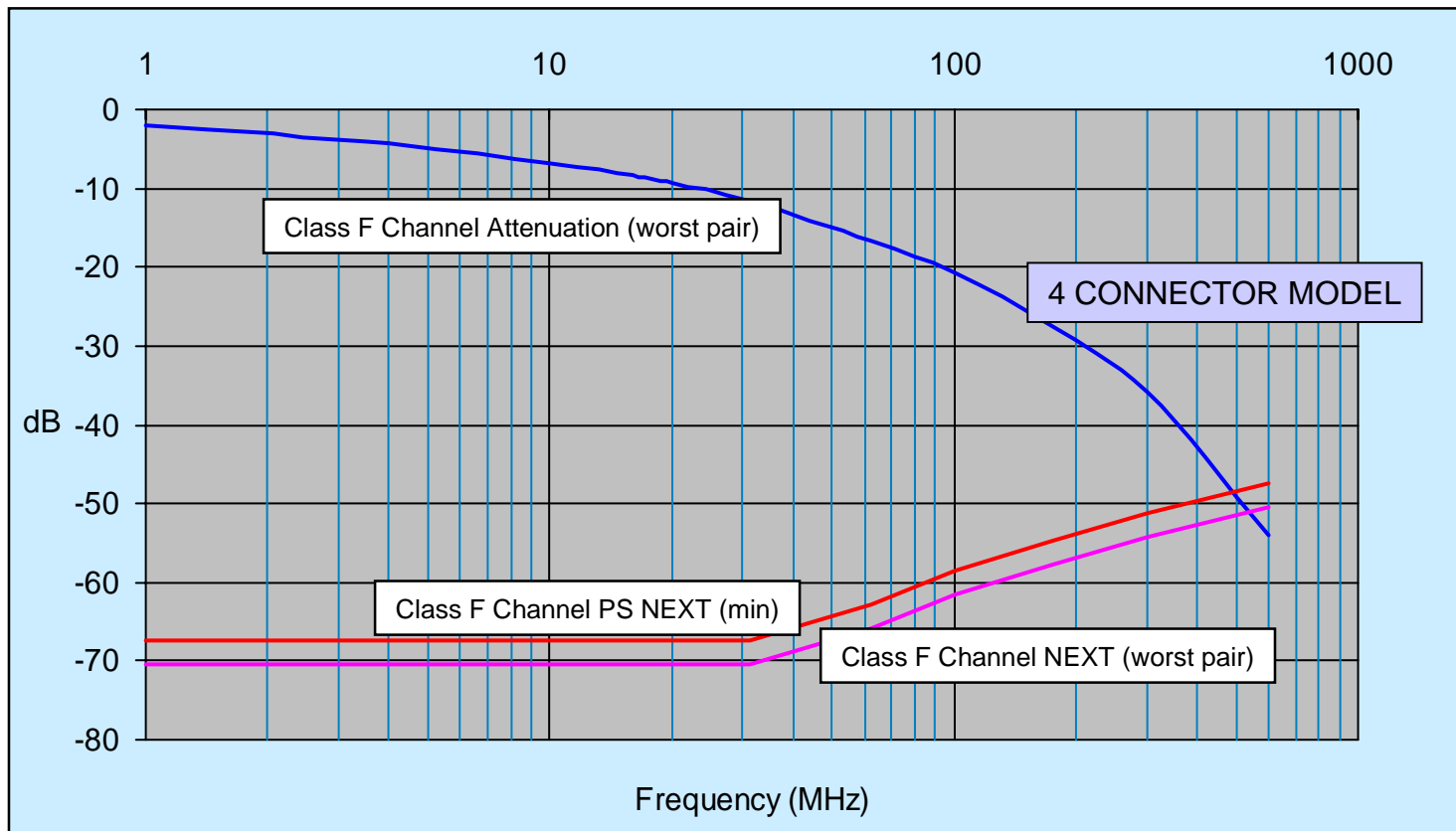
Existing standards text from BS EN 50173 (1995)

„Cables and connecting hardware of different categories may be mixed  
within a subsystem and/or the cabling link, but the transmission characteristics  
of the link will be determined by the category of the least performing component.“



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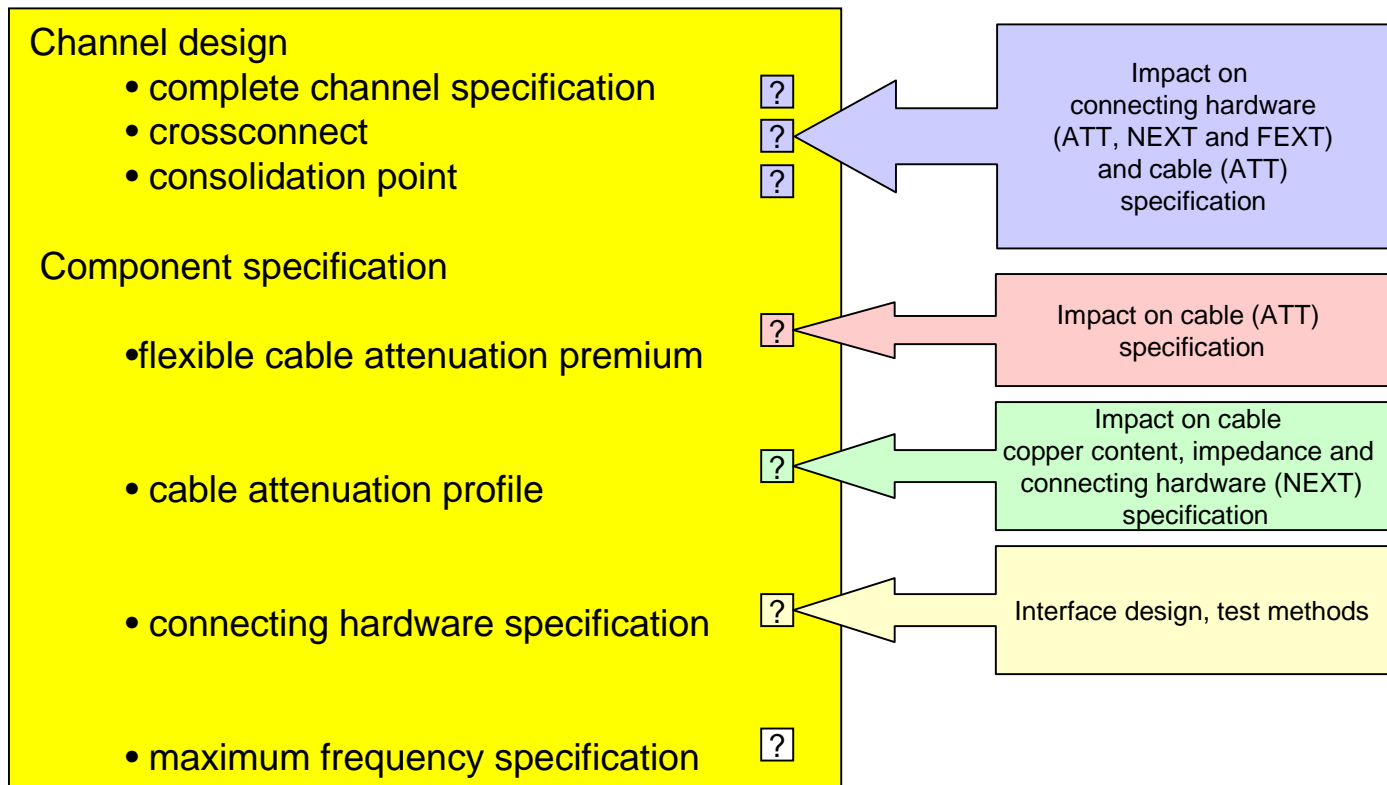
# Class F Channel (Munich)





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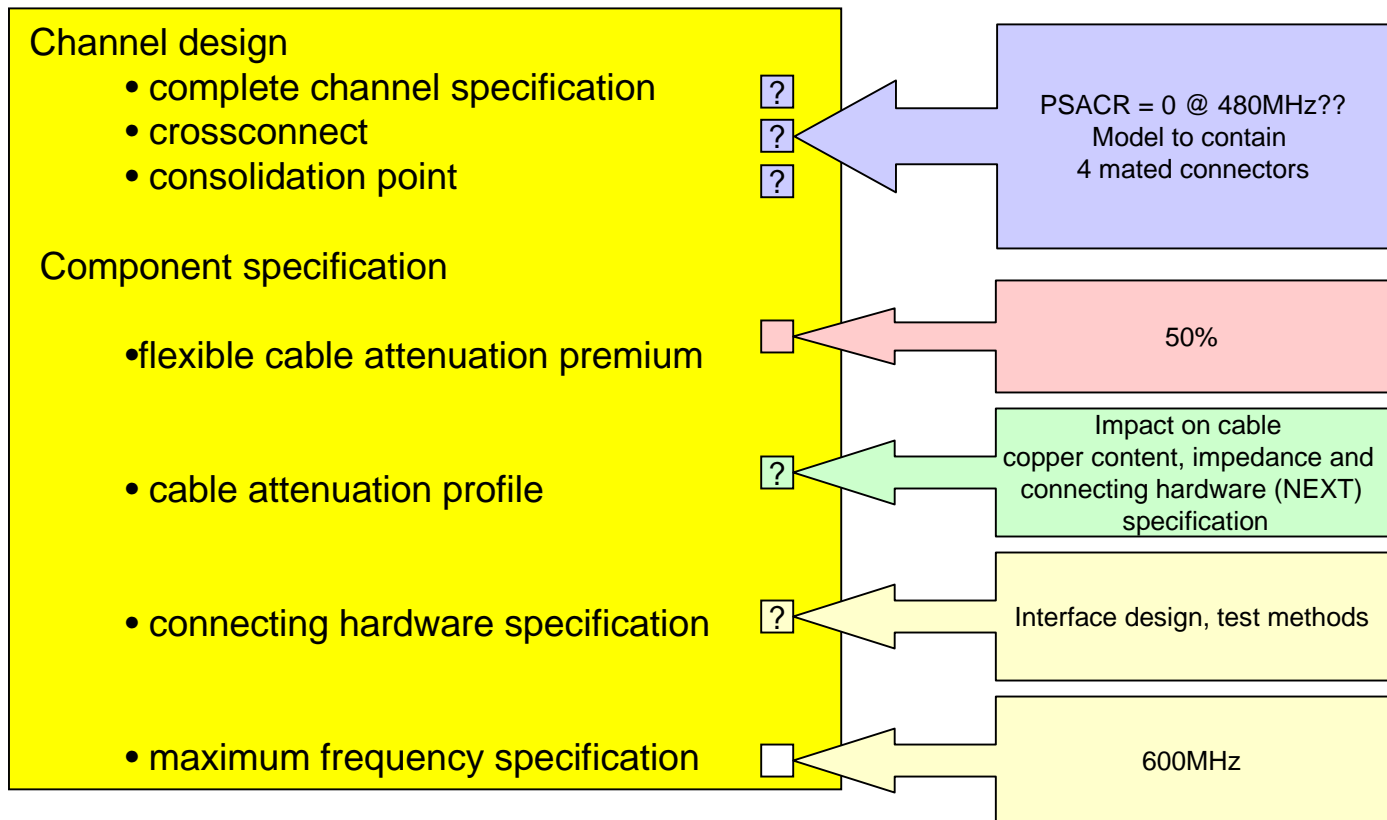
# Cat. 7 Action Items, 03/98





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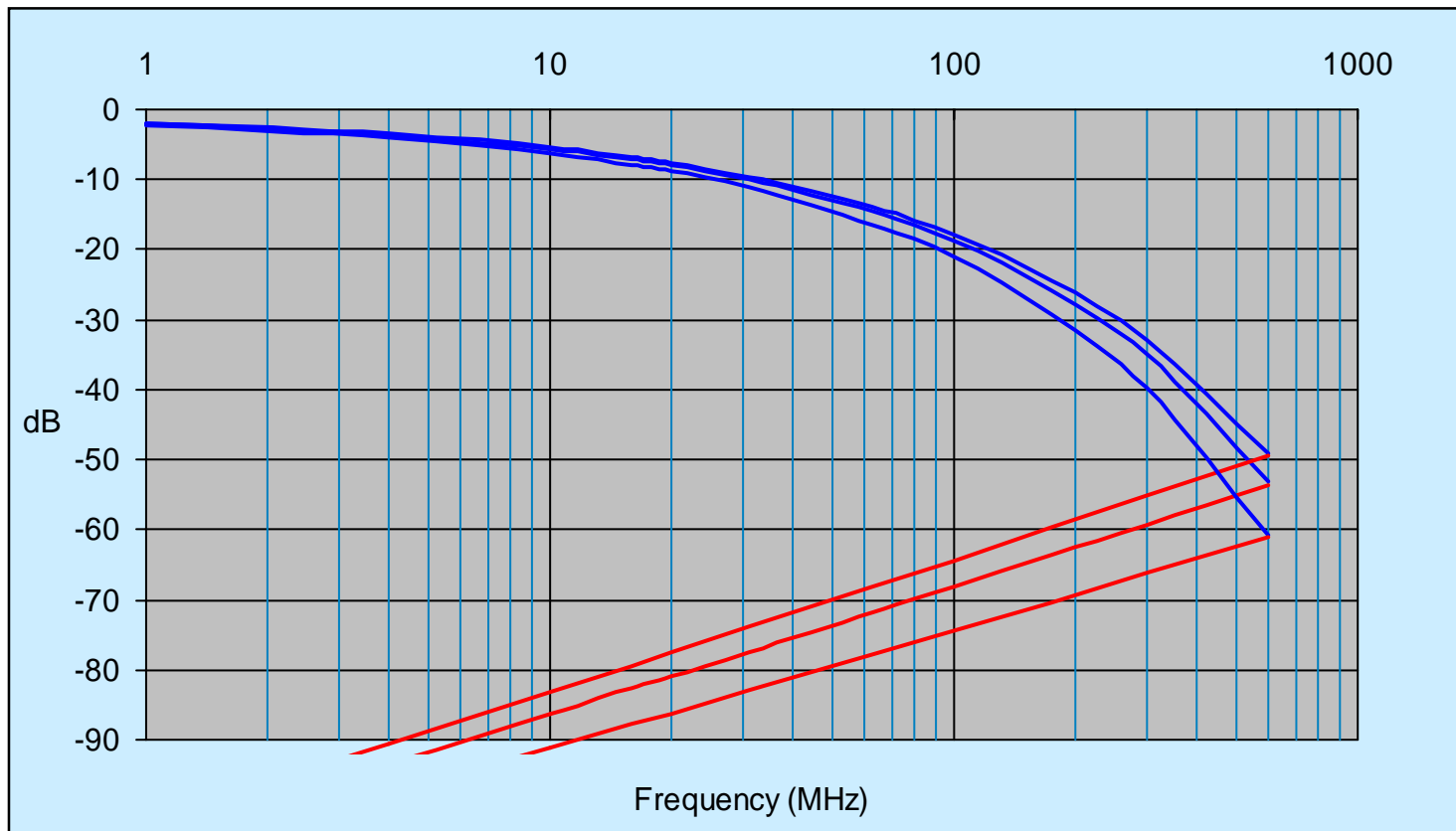
# Cat. 7 Status, Tokyo 05/98





DATA CABLING - STILL IN THE MELTING POT?

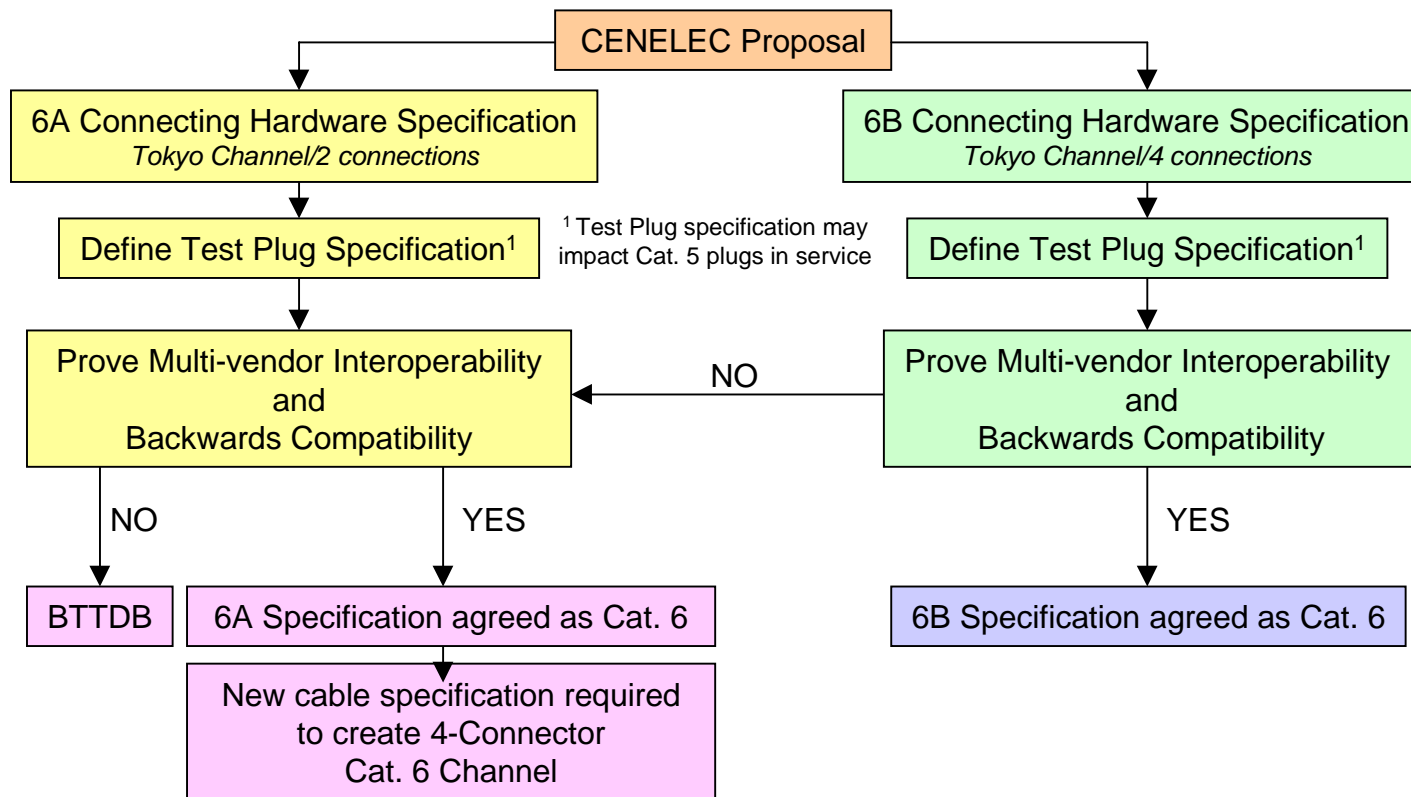
# Class F Alternatives





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# Cat. 6 - The Way Ahead





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# Cat. 7 - The Way Ahead

- agreements required
  - 480MHz or 600MHz
  - PSACR or ACR
  - 4 connectors or 2 connectors
- critical issues
  - interface specification
    - specification and selection of connecting hardware
    - failure to agree could produce default option
      - RJ45
      - 2 pairs
  - testing
    - certain parameters appear impossible to test “cost effectively”



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# Proprietary Solutions

- NO products claiming Cat. 6 conformance
  - can guarantee to meet final figures
    - may fail Cat. 6 tests when available
  - can guarantee interoperability with other Cat. 6 products
  - can guarantee backwards compatibility
- all such products represent proprietary solutions
  - procurement of network configuration components may be restrictive



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# Agenda

## Session One

**Cat. 5 (1998)**

-

**The Final Figures**

Break

**Cat. 6 and Cat. 7**

-

**The Way Ahead**

**QUESTIONS**

## Session Two

**Optical Fibres Planning**

-

**Guidance At Last**

Break

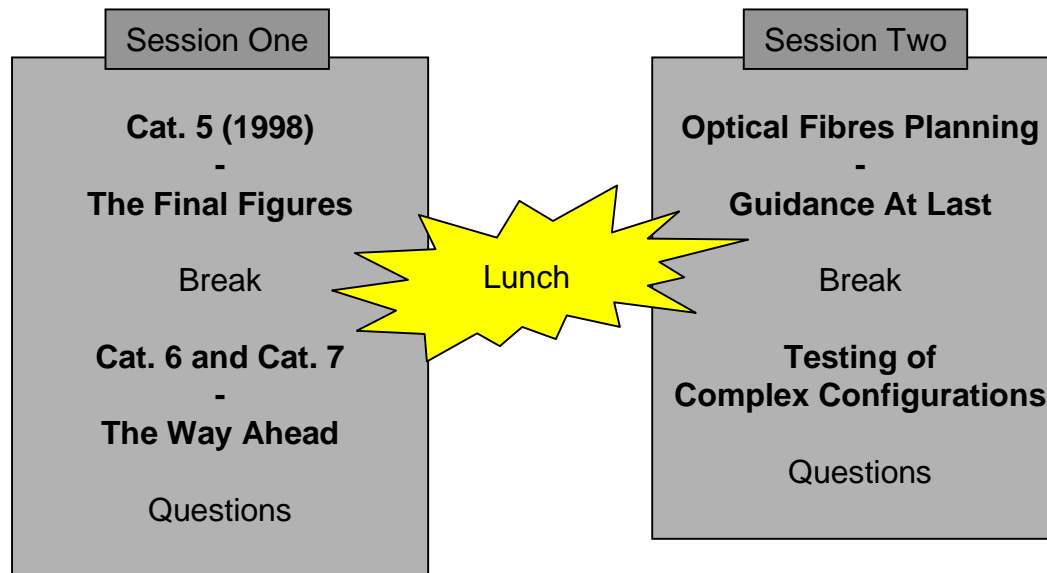
**Testing of  
Complex Configurations**

Questions



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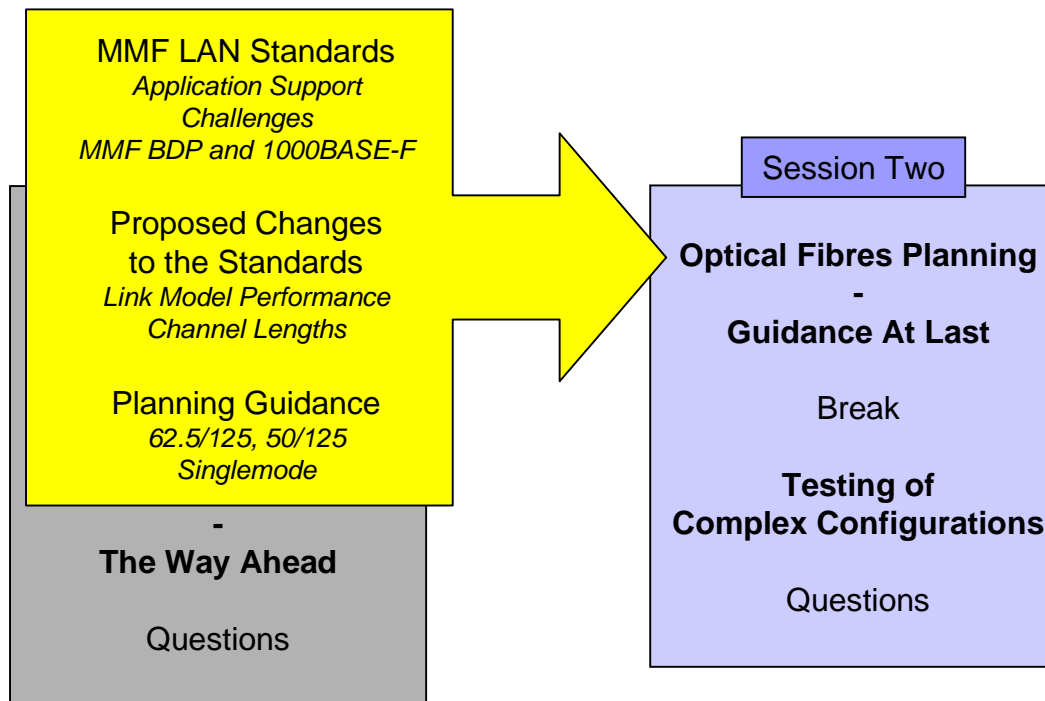
# Agenda

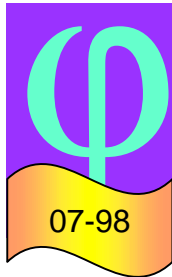




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# MMF LAN Standards

## First Window (850nm)

4Mb/s:	Token Ring
10Mb/s:	FOIRL 10BASE-FL/FB
16Mb/s:	Token Ring
100Mb/s:	100BASE-VG AnyLAN
155Mb/s:	ATM (Asynchronous Transfer Mode)
266Mb/s:	FiberChannel
531Mb/s:	FiberChannel
622Mb/s:	ATM (Asynchronous Transfer Mode)
1000Mb/s:	1000BASE-SX
1062Mb/s:	FiberChannel

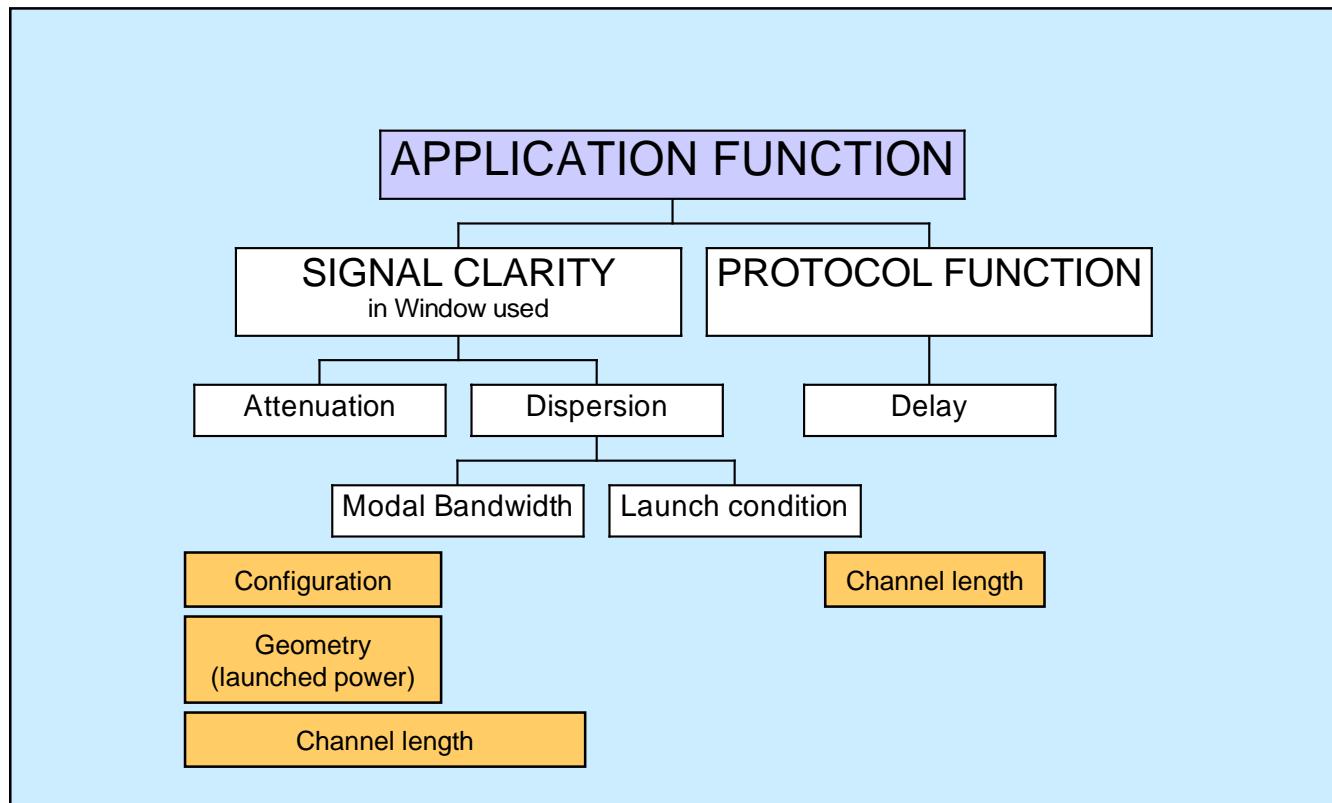
## Second Window (1300nm)

52Mb/s:	ATM (Asynchronous Transfer Mode)
100Mb/s:	100BASE-VG AnyLAN 100BASE-FX FDDI
133Mb/s:	FiberChannel
155Mb/s:	ATM
266Mb/s:	FiberChannel
622Mb/s:	ATM
1000Mb/s:	100BASE-LX



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# MMF Application Support





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# Challenges for Optical Fibre

- MMF bandwidth
  - latest applications are “bandwidth limited”
  - most users are “bandwidth ignorant”
- “standards” support
  - based upon “attenuation limited” applications
- revision required
  - component specification
  - channel models
  - selection rules
    - components
    - equipment



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# MMF BDP and 1000BASE-F

Geometry ( $\mu\text{m}$ )	B (MHzkm) 850nm	B (MHzkm) 1300nm
62.5/125 (ANSI/TIA/EIA 568A)	160	500
IS 11801/EN 50173	200	500

## 1000BASE-SX

- 1st window (850nm)
- CD LASER/VCSEL

62.5/125

- 220 metres for 160MHzkm
- 275 metres for 200MHzkm

## 1000BASE-LX

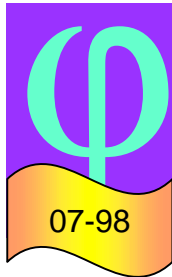
- 2nd window (1300nm)
- SM LASER

62.5/125

- 550 metres for 500MHzkm

A recent survey by IEC found a total of  
73 (50/125) and 43 (62.5/125) dual window combinations  
in production throughout the world

**MANY OF WHICH WERE BELOW THE SPECIFICATIONS QUOTED ABOVE**



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# MMF Standard Specifications

Geometry (μm)	B (MHzkm) 850nm	B (MHzkm) 1300nm
62.5/125	160	200
<b>62.5/125 (ANSI/TIA/EIA 568A)</b>	<b>160</b>	<b>500</b>
62.5/125	200	200
50/125 and 62.5/125	200	400
<b>IS 11801/EN 50173</b>	<b>200</b>	<b>500</b>
50/125 and 62.5/125	200	600
62.5/125	250	1000
62.5/125	300	800
50/125	400	400
50/125	400	600
50/125	400	800
50/125	400	1000
50/125	400	1200
50/125	400	1500
<b>50/125 (proposed IS 11801/EN 50173)</b>	<b>500</b>	<b>500</b>
50/125	600	1000

Geometry (μm)	α (dB/km) 850nm	α (dB/km) 1300nm
50/125	2.4	0.6
50/125	2.5	0.8
50/125	2.7	1.0
62.5/125	3.0	0.7
62.5/125	3.2	0.9
<b>IS 11801/ EN 50173</b>	<b>3.5</b>	<b>1.0</b>
<b>ANSI/TIA/EIA 568A</b>	<b>3.75</b>	<b>1.5</b>



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# OF Connector Standards

Type	Plug	Interface
F-SMA	IEC60874-02	
CF-03	IEC60874-03	
CF-04	IEC60874-04	
BAM	IEC60874-05	
LSA	IEC60874-06	IEC61754-3
FC	IEC60874-07	
D	IEC60874-08	
OF-2	IEC60874-09	
<b>BFOC/2,5</b>	<b>IEC60874-10</b>	<b>IEC61754-2</b>
OCCA-PC	IEC60874-11	
OCCA-BU	IEC60874-12	
CF-08	IEC60874-13	IEC61754-8
SC	IEC60874-14	IEC61754-4
DS	IEC60874-15	IEC61754-9
MT	IEC60874-16	IEC61754-5
F-05	IEC60874-17	
<b>SC-D (duplex)</b>	<b>IEC60874-19</b>	
MU		IEC61754-6
MPO		IEC61754-7

## IS 11801 and EN 50173

### TO Type (MMF, SMF)

#### Green field:

#### SC Duplex

BS EN 60874-19

IEC 60874-19

#### Legacy:

#### BFOC/2,5 (ST)

BS EN 60874-10, BS EN 61754-2

IEC 60874-10, IEC 61754-2

### Mated connection

**Installed attenuation (MMF, SMF) = 0.75dB maximum**

**Return loss (MMF) = 20dB minimum**

**Return loss (SMF) = 26dB minimum**

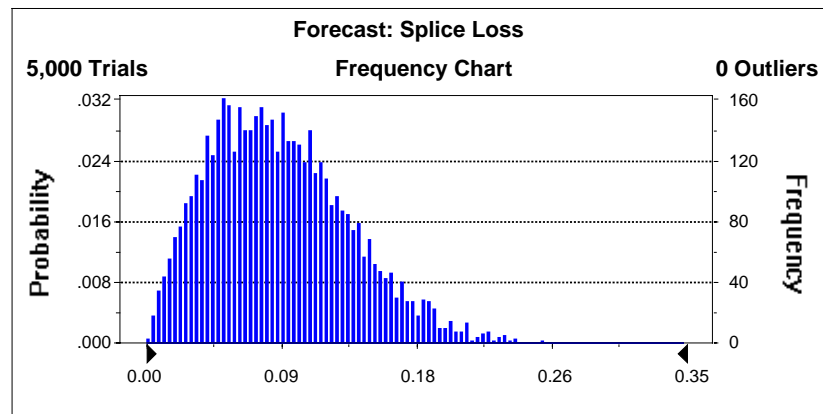
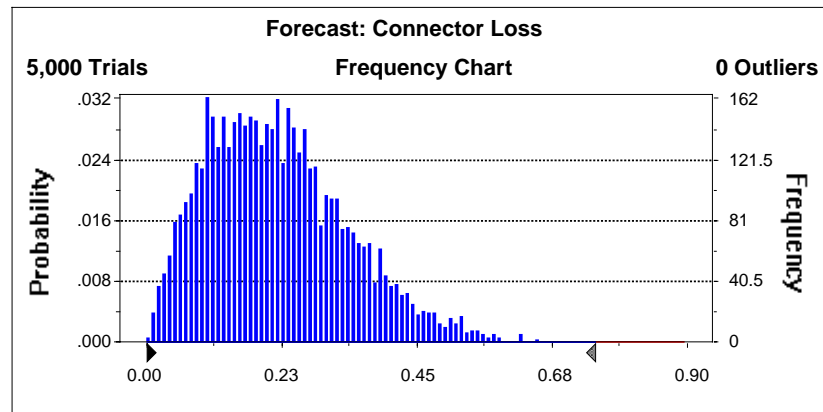
### Splice

**Attenuation (MMF and SMF) = 0.3dB maximum**



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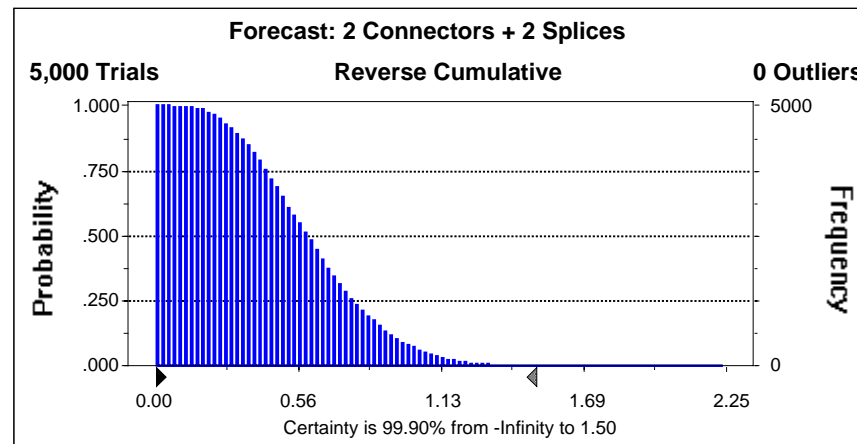
# Component Distributions





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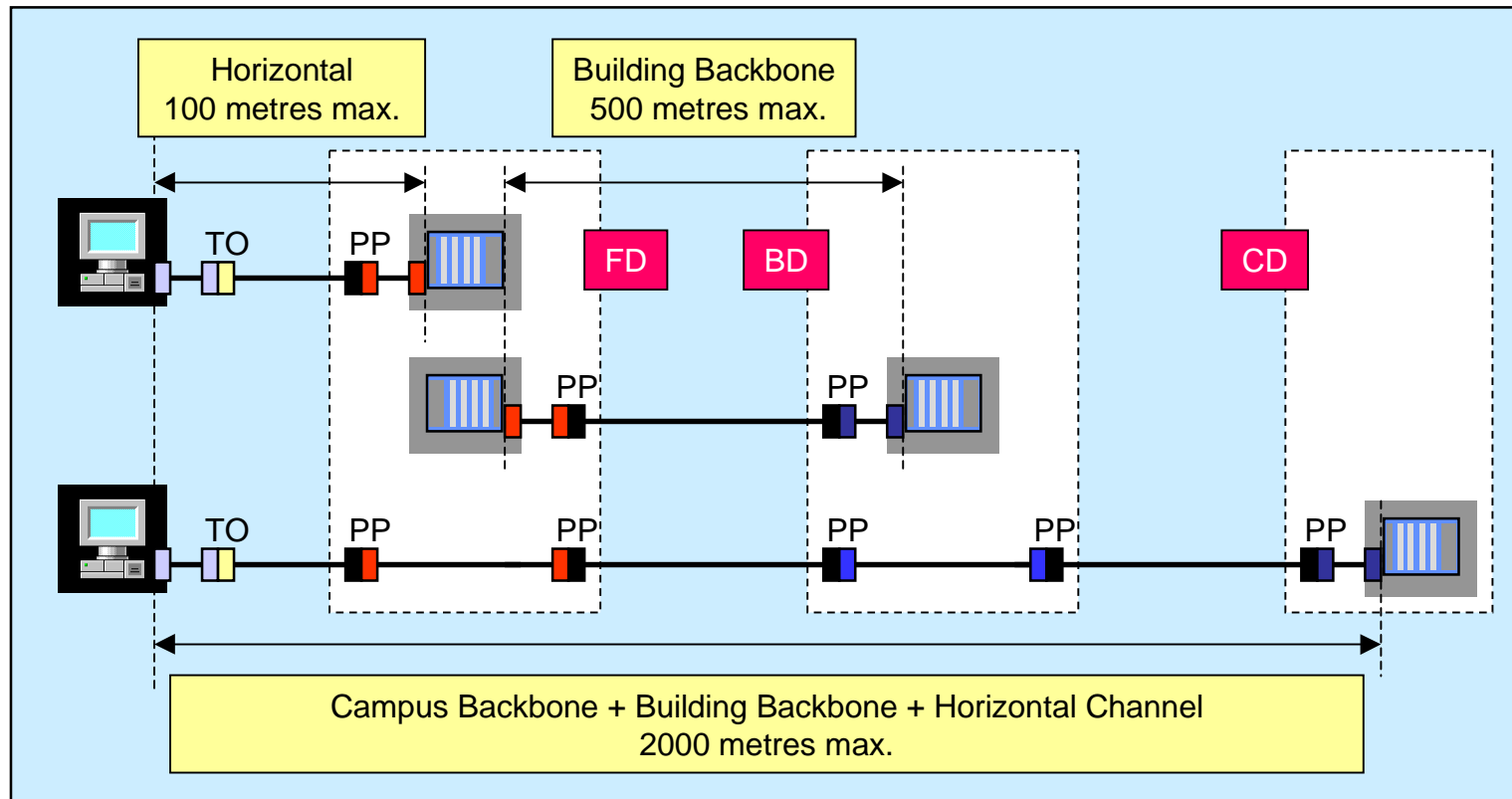
# Optical Fibre Link Model





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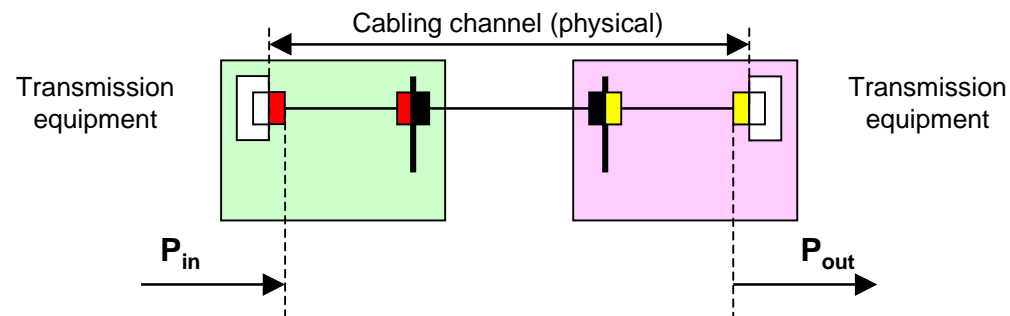
# Cabling Channel Dimensions





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# Optical Loss Budget



$$\text{Optical Power Budget (OPB)} = P_{in} - P_{out} \text{ (dB)}$$

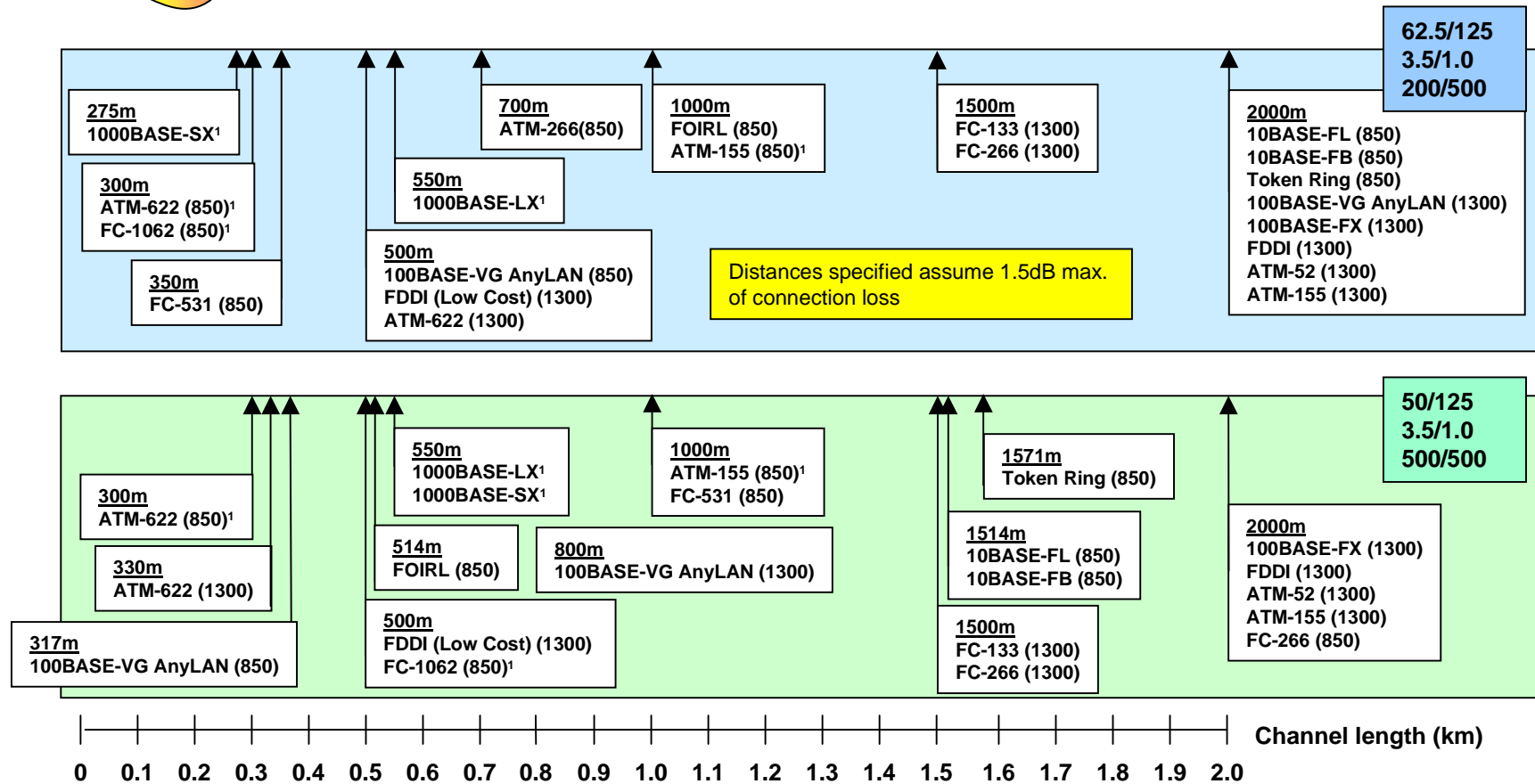
- specified for standardised applications
- dependent on optical fibre design

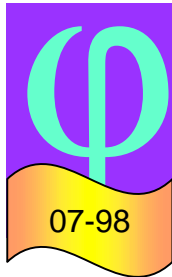
$$\text{Channel length} = (\text{OPB} - \text{total connection loss}) / \text{cable attenuation}$$



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# MMF Application Channels





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# MMF Application OLB

APPLICATION	Wave-length (nm)	62.5/125 3.5/1.5 dB/km 200/500 MHzkm		50/125 3.5/1.5 dB/km 500/500 MHzkm	
		Channel length (m)	OLB (dB)	Channel length (m)	OLB (dB)
Distances specified assume 1.5dB max. of connection loss					
ISO/IEC 9314-3: FDDI PMD	1300	2000	11.0	2000	6.0
ISO/IEC 8802-3: 100BASE-FX	1300	2000	11.0	2000	6.0
ISO/IEC 8802-3:10BASE-FL & FB	850	2000	12.5	1514	6.8
ISO/IEC TR 11802-4: 4 & 16 Mb/s Token Ring	850	2000	12.0	1571	7.0
ATM @ 52 Mb/s	1300	2000	10.0	2000	5.3
ATM @ 155 Mb/s	1300	2000	10.0	2000	5.3
IEEE 802.12: Demand Priority	1300	2000	7.0	800	2.3
CD 14165-1: Fibre Channel (FC-PH) @ 266 Mb/s	1300	1500	6.0	1000	5.5
CD 14165-1: Fibre Channel (FC-PH) @ 133 Mb/s	1300	1500	6.0	-	1.3
<b>ATM @ 155 Mb/s<sup>1</sup></b>	850	1000	7.2	1000	7.2
ISO/IEC 8802-3: FOIRL	850	1000	9.0	514	3.3
CD 14165-1: Fibre Channel (FC-PH) @ 266 Mb/s	850	700	12.0	1500	12.0
<b>IEEE 802.3: 1000BASE-LX<sup>1</sup></b>	1300	550	2.35	550	2.35
CD 9314-9: FDDI LCF-PMD	1300	500	7.0	500	2.0
IEEE 802.12: Demand Priority	850	500	7.5	371	2.8
ATM @ 622 Mb/s	1300	500	6.0	330	2.0
CD 14165-1: Fibre Channel (FC-PH) @ 531 Mb/s	850	350	8.0	1500	8.0
<b>ATM @ 622 Mb/s<sup>1</sup></b>	850	300	4.0	300	4.0
<b>CD 14165-1: Fibre Channel (FC-PH) @ 1062 Mb/s<sup>1</sup></b>	850	300	4.0	300	4.0
<b>IEEE 802.3: 1000BASE-SX<sup>1</sup></b>	850	275	2.6	550	3.56

1

These applications are bandwidth limited at the channel lengths shown. The use of lower attenuation components to produce channels exceeding the values shown cannot be recommended.

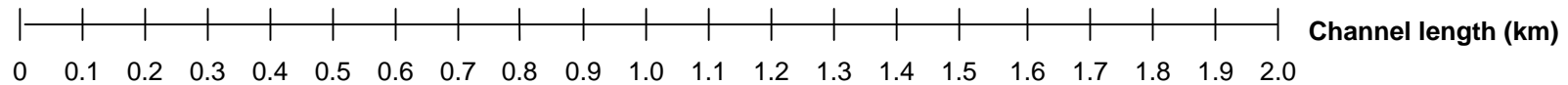


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# SMF Application Support

10/125

- 2000m
- FDDI (1300)
- ATM-52 (1300)
- ATM-155 (1300)
- ATM-622 (1300)
- FC-266 (1300)
- FC-531 (1300)
- FC-1062 (1300)
- 1000BASE-LX (1300)



APPLICATION	Wave-length (nm)	10/125 0.5/1.0 dB/km	Channel length (m)	OLB (dB)
DIS 9314-4: FDDI SMF-PMD	1310		2000	10.0 <sup>1</sup>
ATM @ 52 Mb/s	1310		2000	7.0 <sup>1</sup>
ATM @ 155 Mb/s	1310		2000	7.0 <sup>1</sup>
ATM @ 622 Mb/s	1310		2000	7.0 <sup>1</sup>
CD 14165-1: Fibre Channel (FC-PH) @ 266 Mb/s	1310		2000	6.0 <sup>1</sup>
CD 14165-1: Fibre Channel (FC-PH) @ 531 Mb/s	1310		2000	14.0 <sup>1</sup>
CD 14165-1: Fibre Channel (FC-PH) @ 1062 Mb/s	1310		2000	6.0 <sup>1</sup>
IEEE 802.3: 1000BASE-LX	1310		2000	4.57

<sup>1</sup> This is the minimum optical loss budget for cabling supported by the applications. Much higher values are also supported in the application standards but lie outside the scope of our standard



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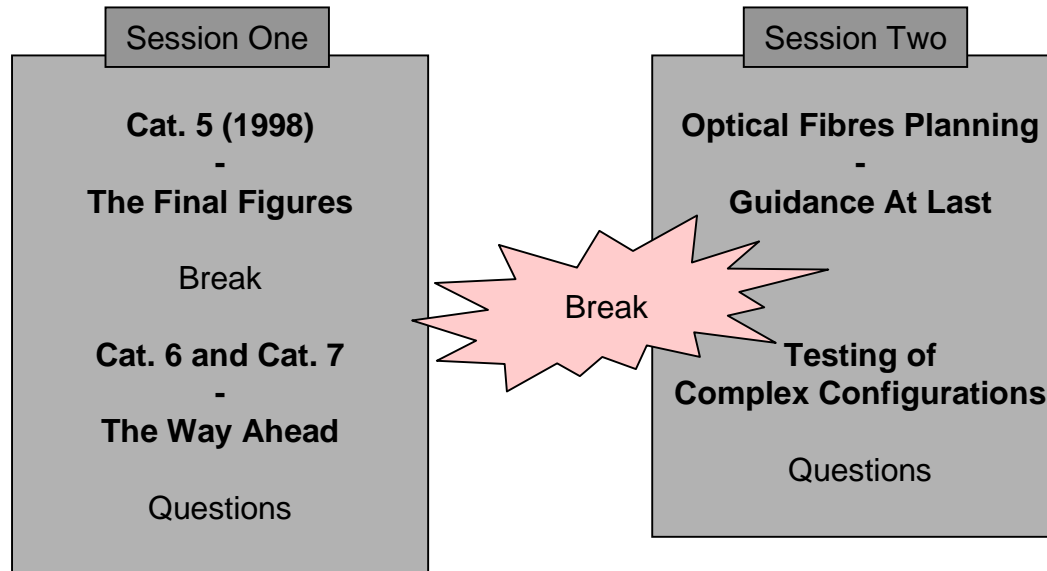
# Optical Fibre Planning

- multimode optical fibre
  - application standards specify
    - minimum channel lengths
      - OLB
      - modal bandwidth
  - equipment suppliers may exceed the values specified
- singlemode optical fibre
  - represents the ultimate technology
    - existing low/medium speed applications have no singlemode options
    - link aggregation is seen as next application development



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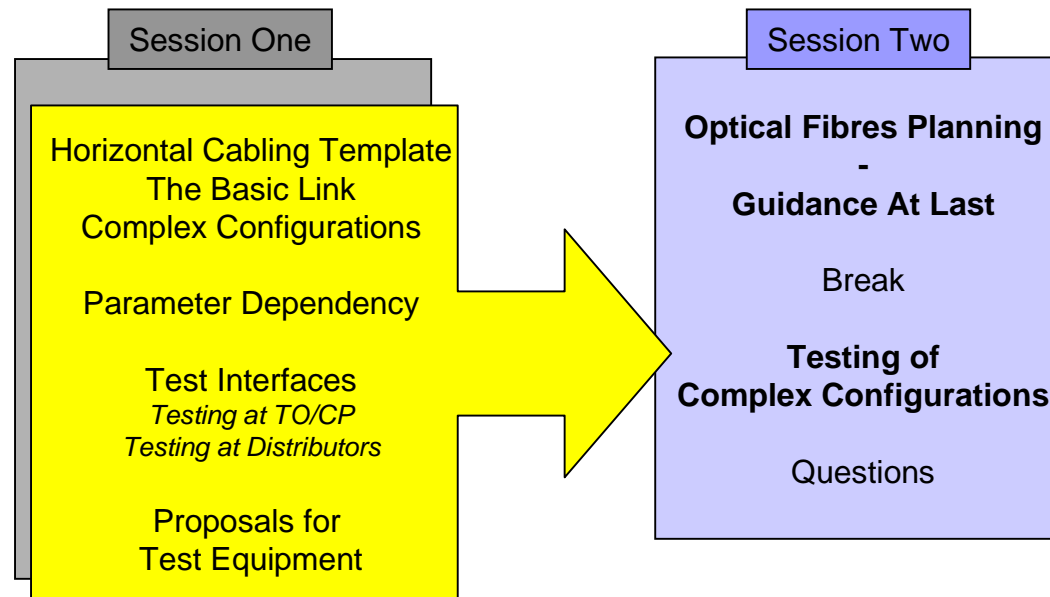
# Agenda





DATA CABLING - STILL IN THE MELTING POT?

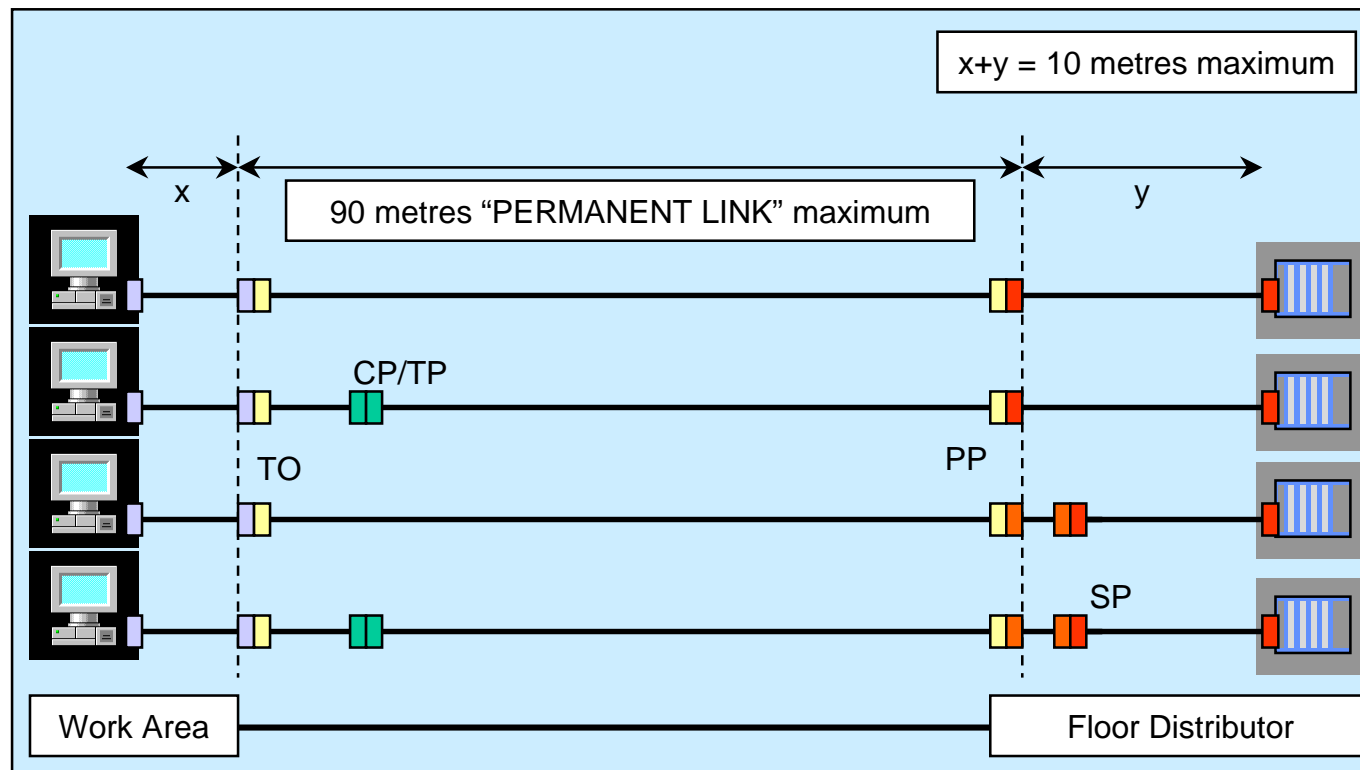
# Agenda





DATA CABLING - STILL IN THE MELTING POT?

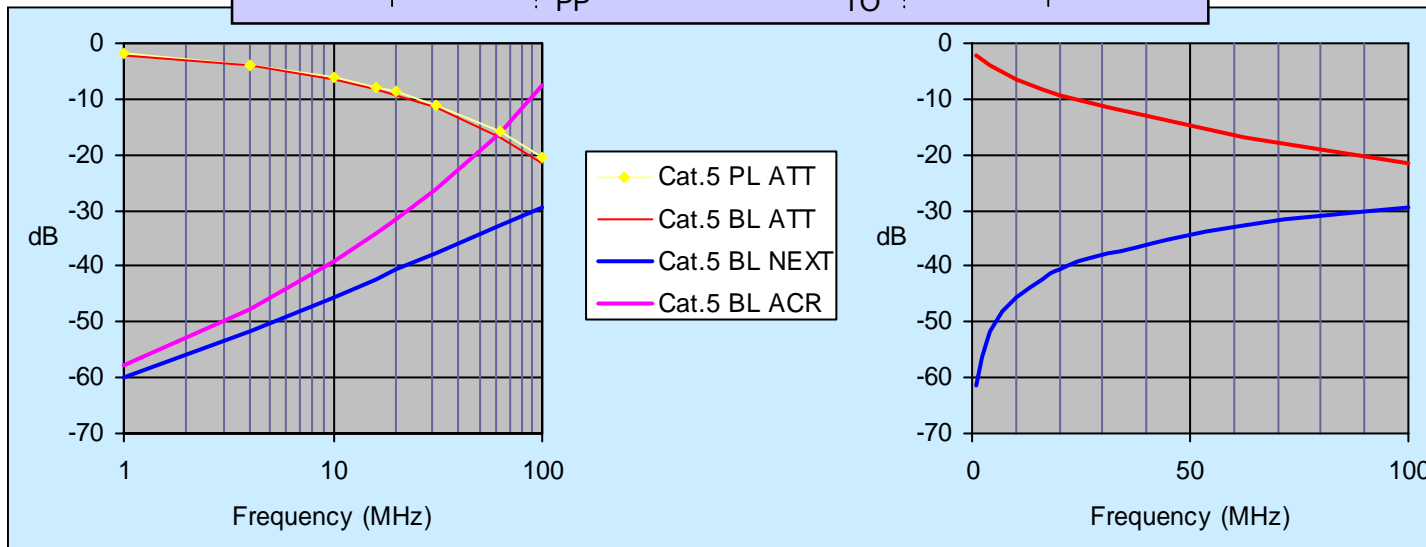
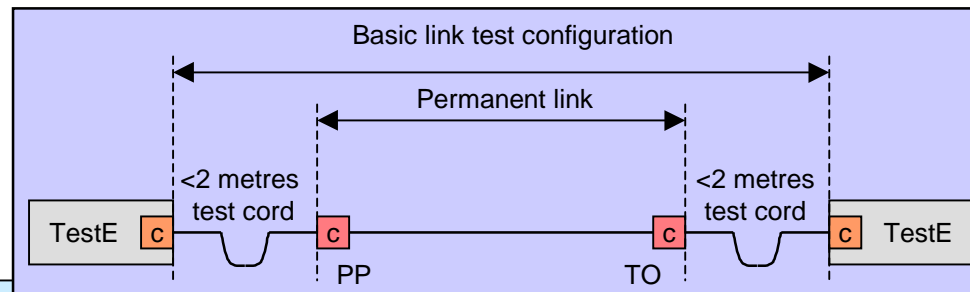
# Horizontal Cabling Template





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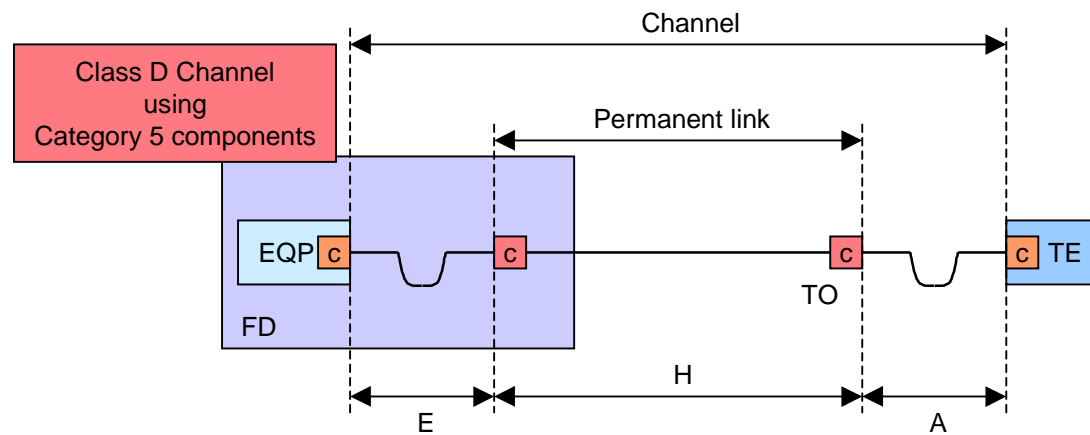
# Category 5 Basic Link Limits





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# Horizontal Channel Rules - 2C



$H = 90$  metres maximum

$$X = A + E$$

$$X = (104 - H)/P$$

or alternatively

$$H = 104 - PX$$

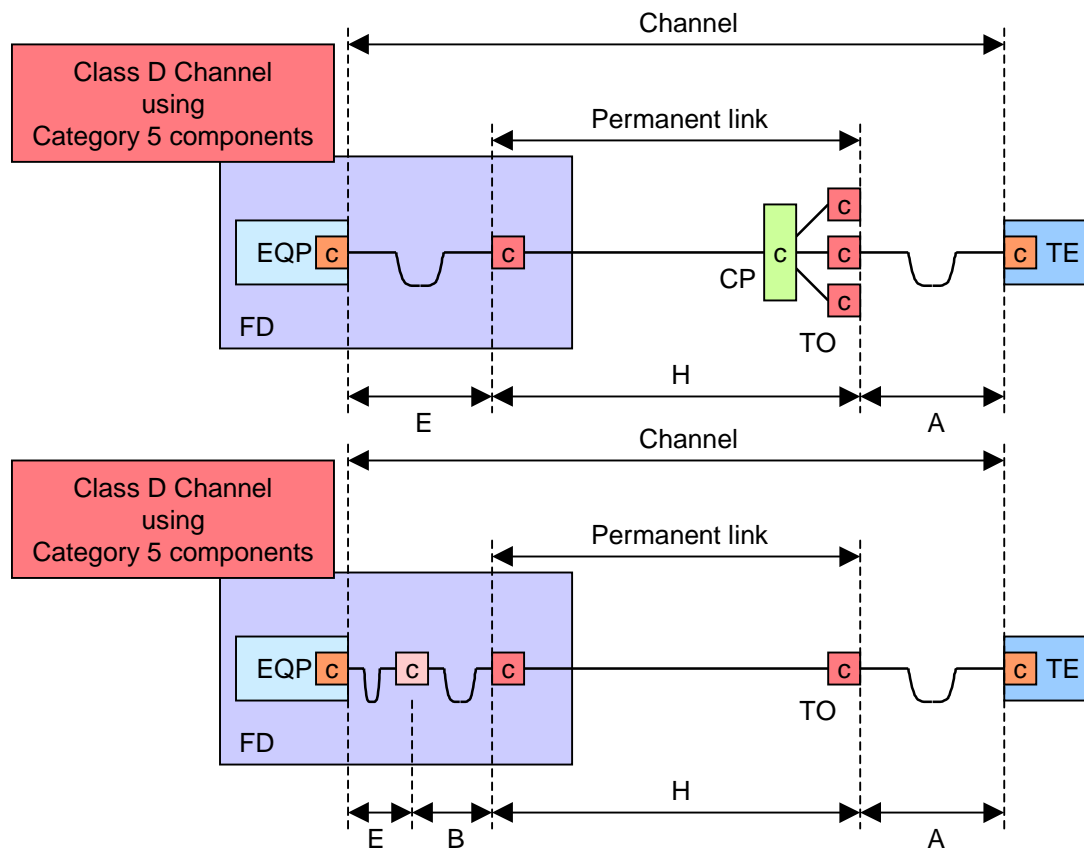
$P = 1.2$  for unscreened cables

$P = 1.5$  for screened cables



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# Horizontal Channel Rules - 3C



Maximum channel length = 100 metres  
 H = 90 metres maximum  
 $X = A+E$   
 $X = (102 - H)/P$   
 or alternatively  
 $H = 102 - PX$

P = 1.2 for unscreened cables

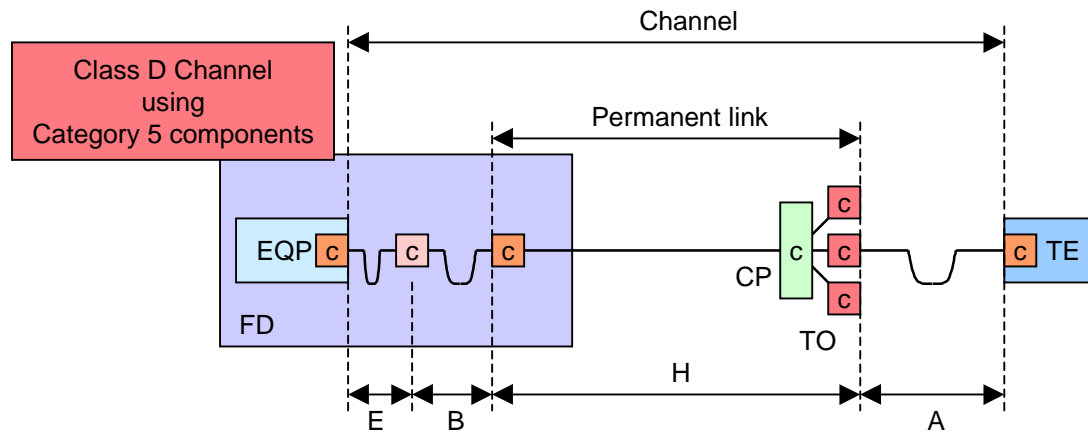
P = 1.5 for screened cables

Maximum channel length = 100 metres  
 H = 90 metres maximum  
 $X = A+B+E$   
 $X = (102 - H)/P$   
 or alternatively  
 $H = 102 - PX$



DATA CABLING - STILL IN THE MELTING POT?

# Horizontal Channel Rules - 4C



Maximum channel length = 100 metres

$H = 90$  metres maximum

$X = A+B+E$

$X = (100 - H)/P$   
or alternatively  
 $H = 100 - PX$

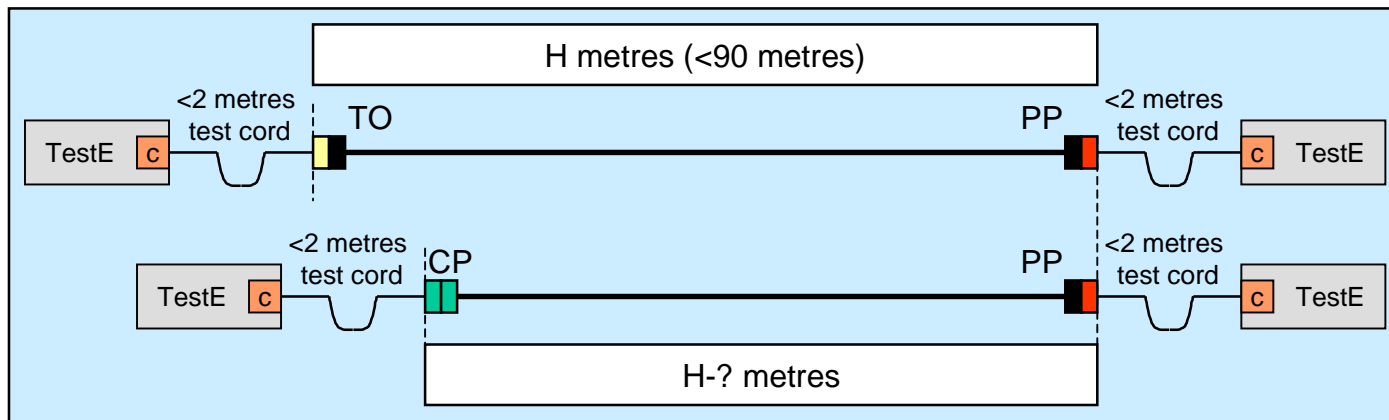
$P = 1.2$  for unscreened cables

$P = 1.5$  for screened cables



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# Real Basic Links





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# Parameter Dependency

## Length/connector-independent parameters

- Wire map

## Length-dependent parameters

- Delay
- Skew
- Attenuation

Test equipment relies on NVP for length calculation

## Length/connector-dependent parameters

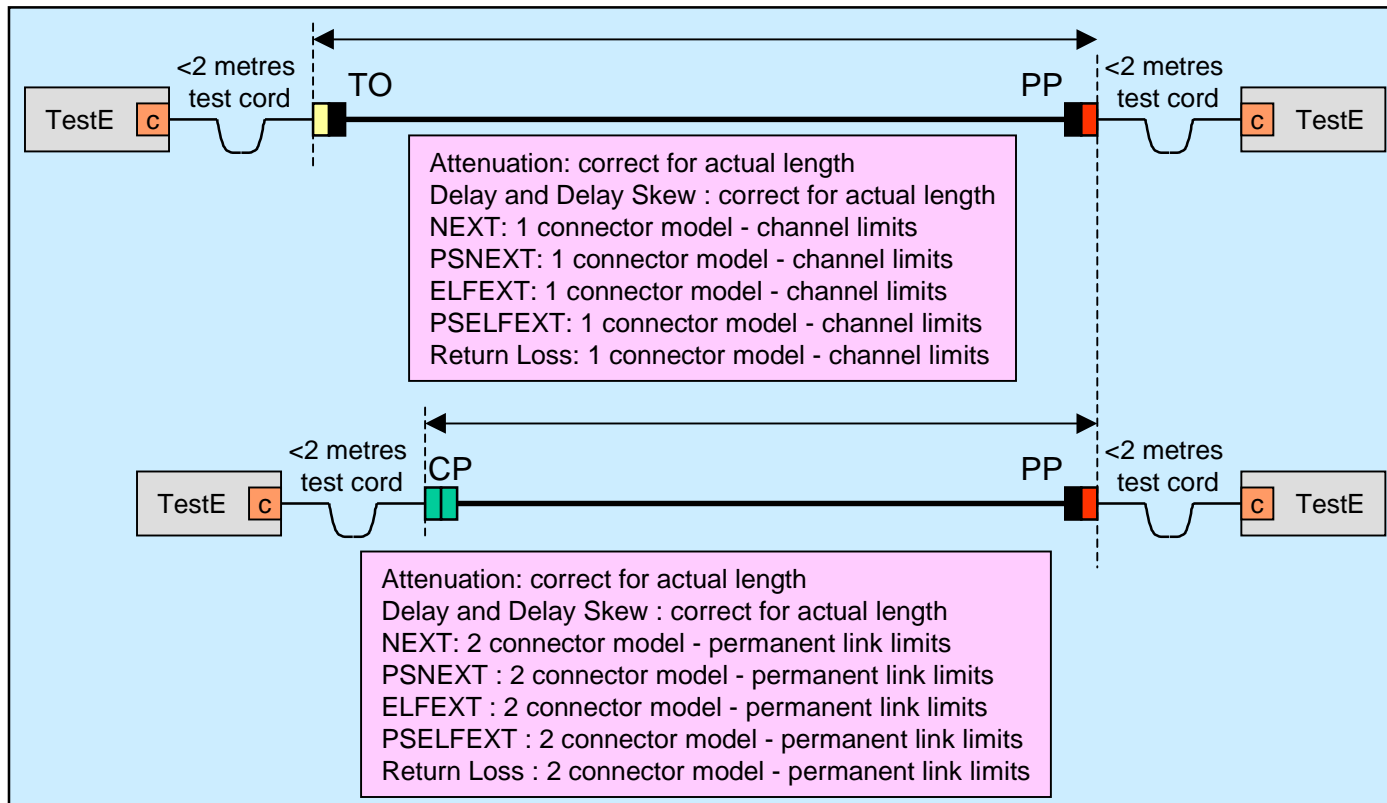
- NEXT
- PSNEXT
- ELFEXT
- PSELFEXT
- Return Loss

Length allowance is complex to compute



DATA CABLING - STILL IN THE MELTING POT?

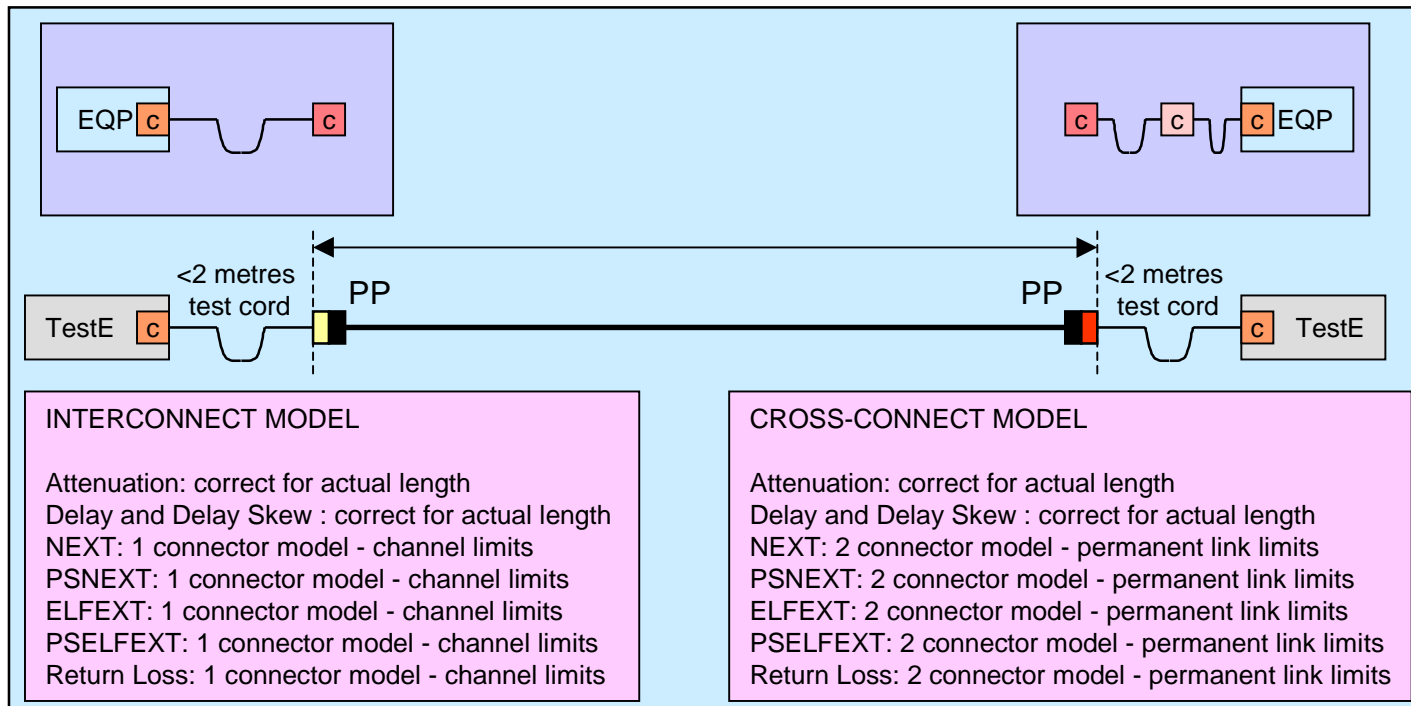
# Measurements at TO/CP





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# Measurements at Distributors





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# Proposals for Test Equipment

- current approach
  - TIA/EIA TSB67
    - include test leads in measured values
    - specify equipment accuracy
- proposed approach
  - ISO/CENELEC revisions
    - exclude test equipment from measured values
    - specify measurement accuracy
- current approach
  - inflexible test regime
- approach under consideration
  - operator set-up to reflect configuration
  - options available
    - 1:1
    - 2:1
    - 1:2
    - 2:2



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The End



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# Agenda

## Session One

**Cat. 5 (1998)**

-

**The Final Figures**

Break

**Cat. 6 and Cat. 7**

-

**The Way Ahead**

Questions

## Session Two

**Optical Fibres Planning**

-

**Guidance At Last**

Break

**Testing of  
Complex Configurations**

**QUESTIONS**