



DATA CABLING - BACK IN THE MELTING POT?

prepared and delivered

by



BSI,

Chiswick, London

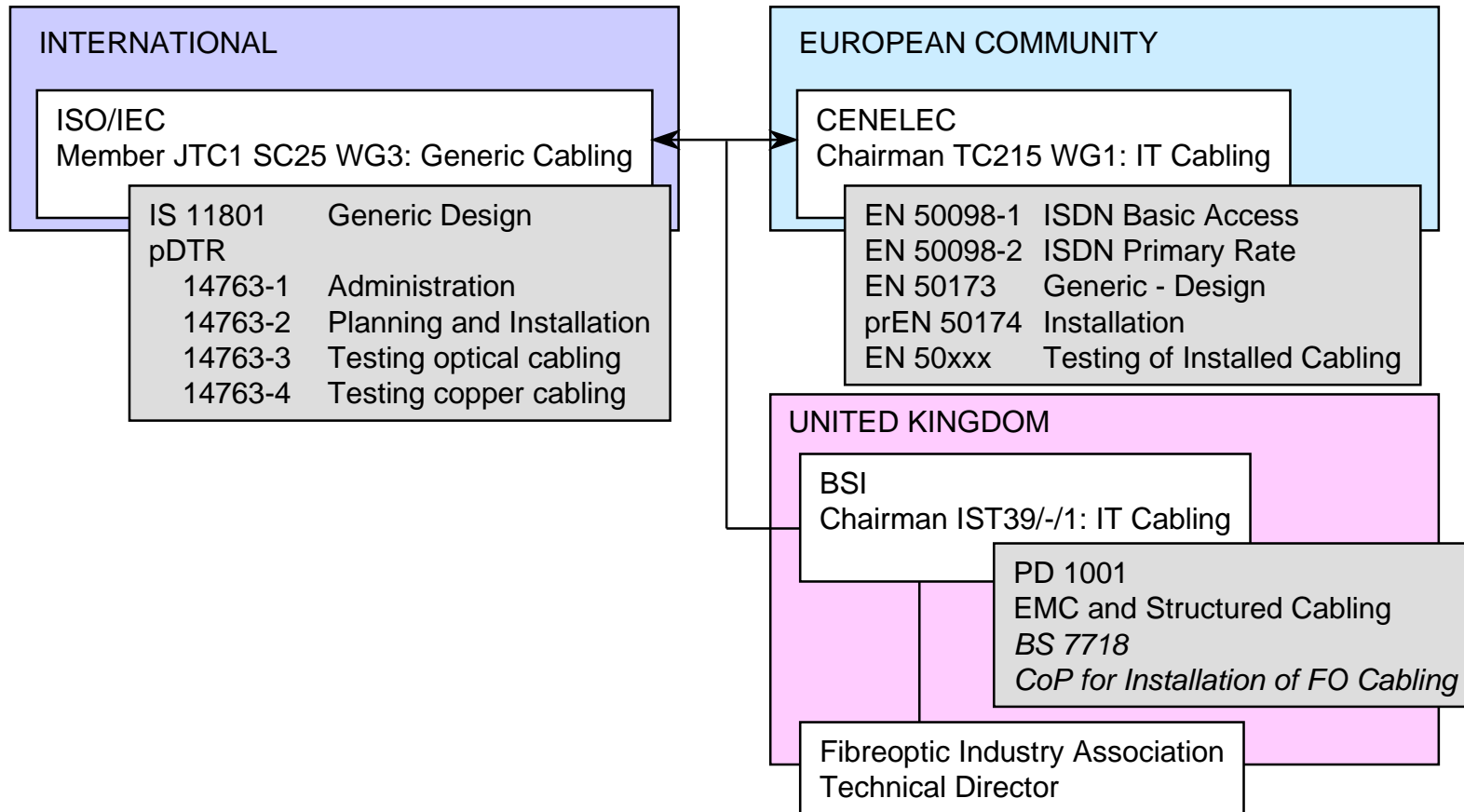
4th March 1998

The Cabling Partnership
© 1998



Mike Gilmore

Senior Partner, The Cabling Partnership





DATA CABLING - BACK IN THE MELTING POT?

Agenda

Session One

Cat. 5+, Cat. 6 and Cat. 7
The story unfolds!

Category 5 (1995)

Complex application support

Category 5 (1998)

-

Category 6 and 7

Current status

Questions

Session Two

Optical Fibres for the Future
50/125, 62.5/125 or singlemode

Cabling performance

Application support

Application development and
equipment choices

-

Design recommendations

Specification and procurement

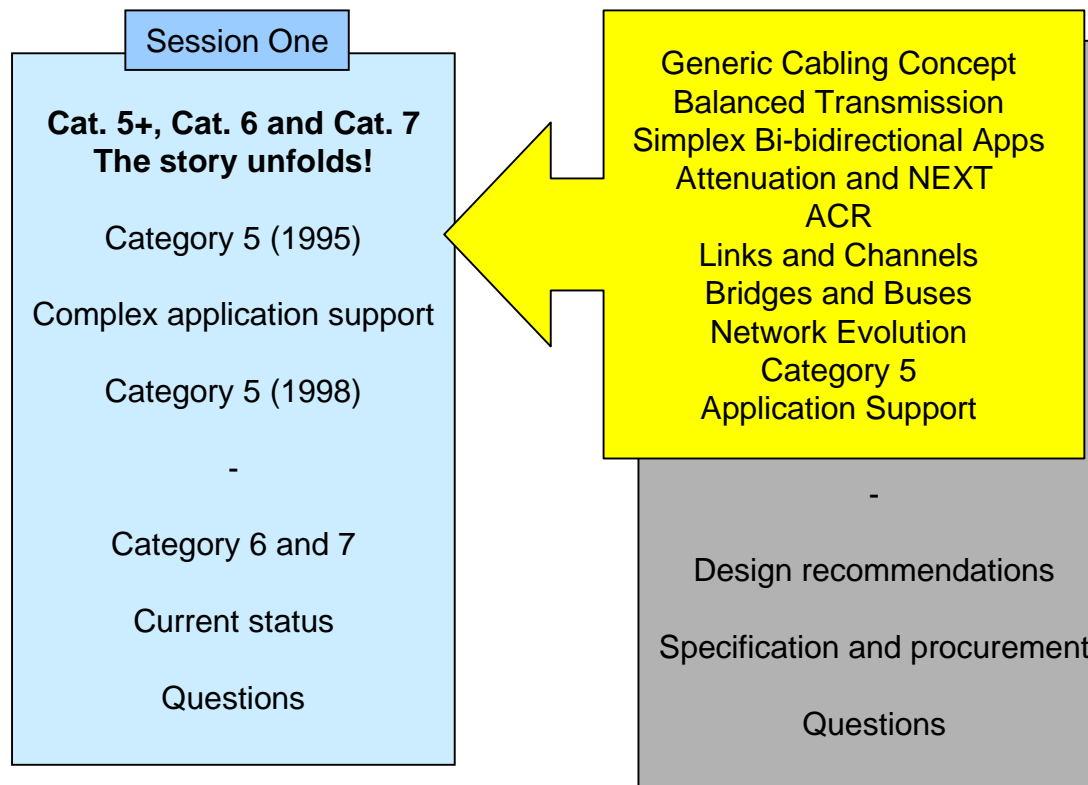
Questions

Lunch



DATA CABLING - BACK IN THE MELTING POT?

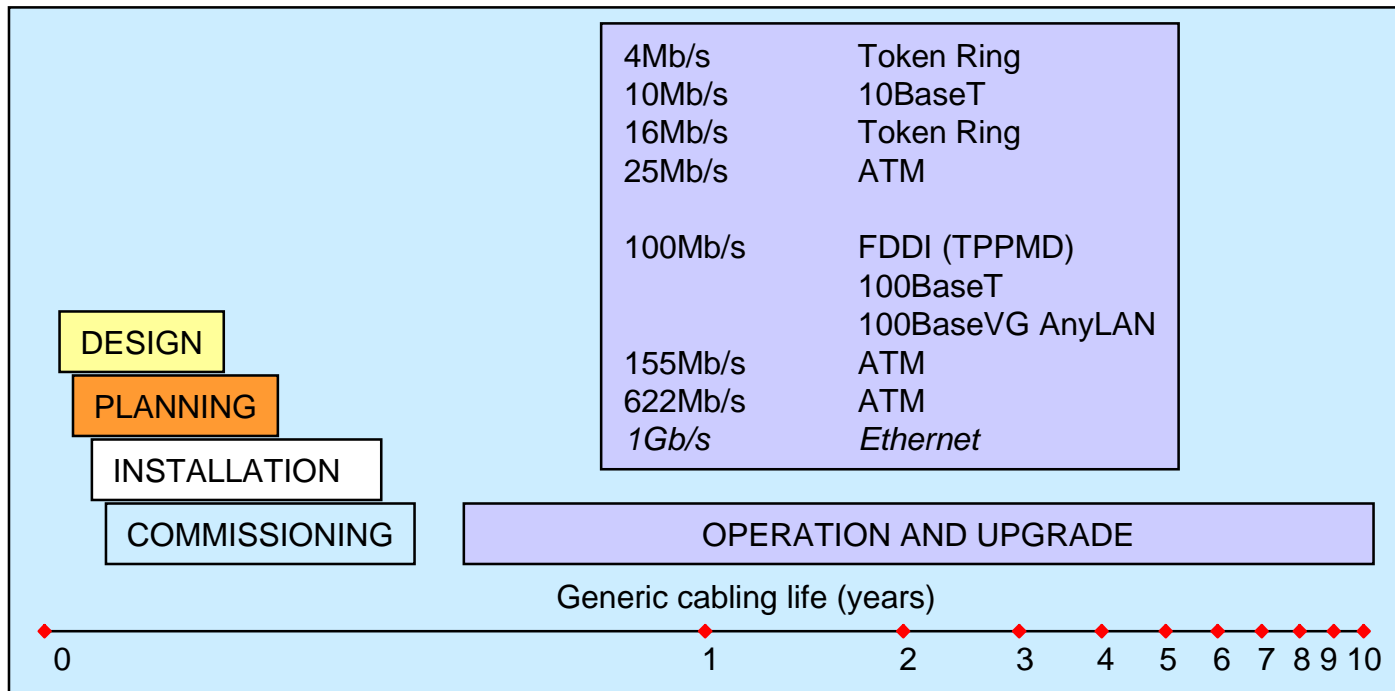
Agenda





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Generic Cabling Concept





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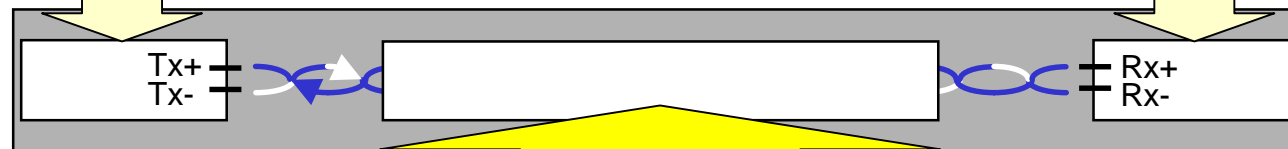
Balanced Transmission

Emission control

Transmitter ensures each conductor carries an equal and opposite current

Immunity control

Receiver only considers difference between the signals on the conductors



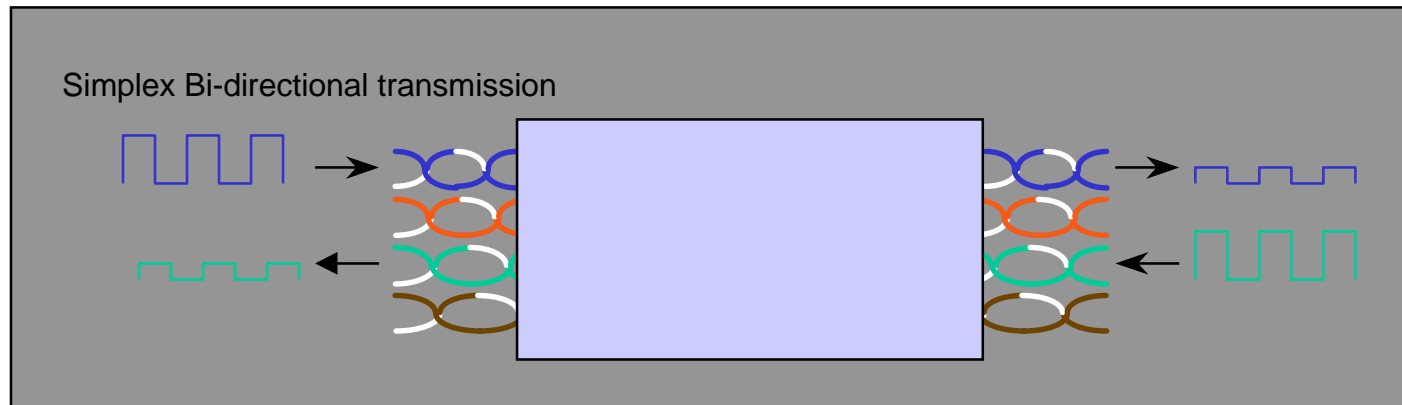
Balanced pair cable seeks to maintain balance of input signal

Minimises inter-pair interference
Controls overall emission and assists immunity provision



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Simplex Bi-directional Apps

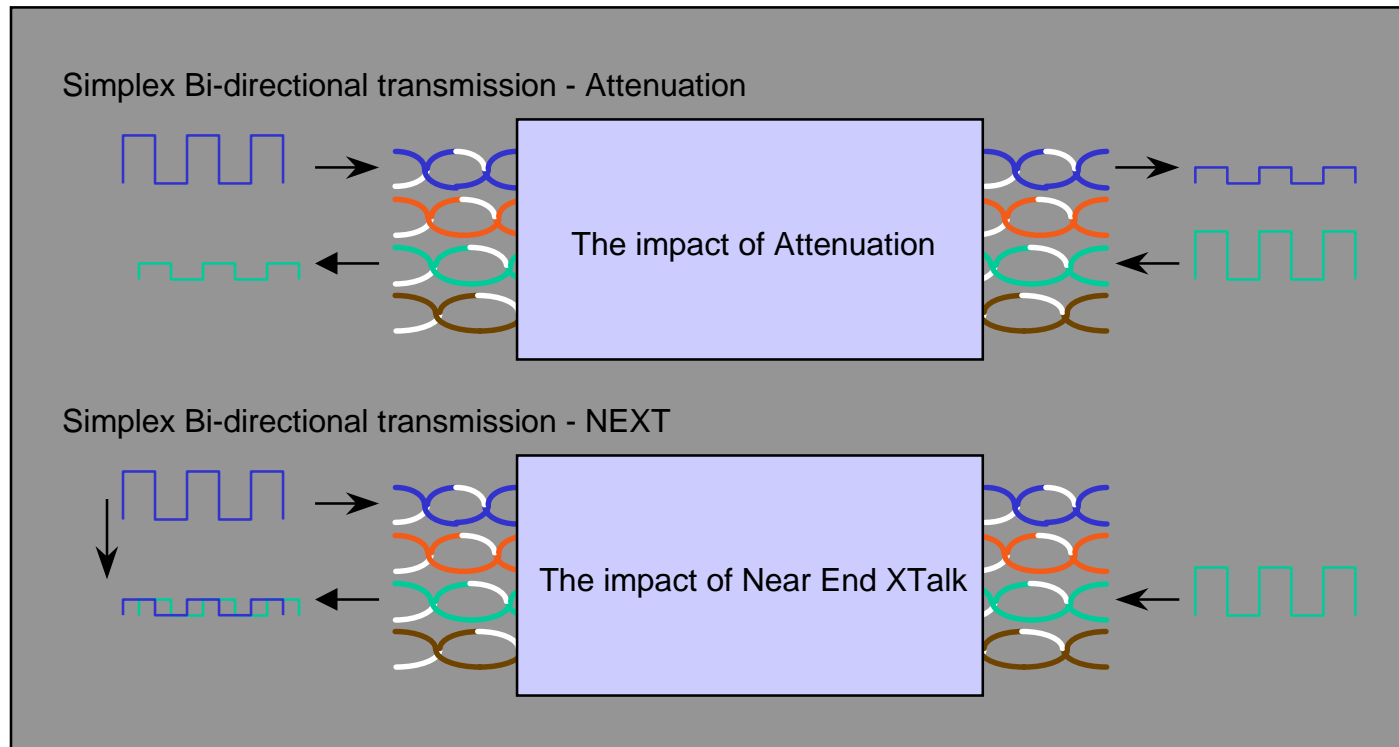


NOTE: transmissions over balanced pairs are not of square wave format



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Attenuation and NEXT

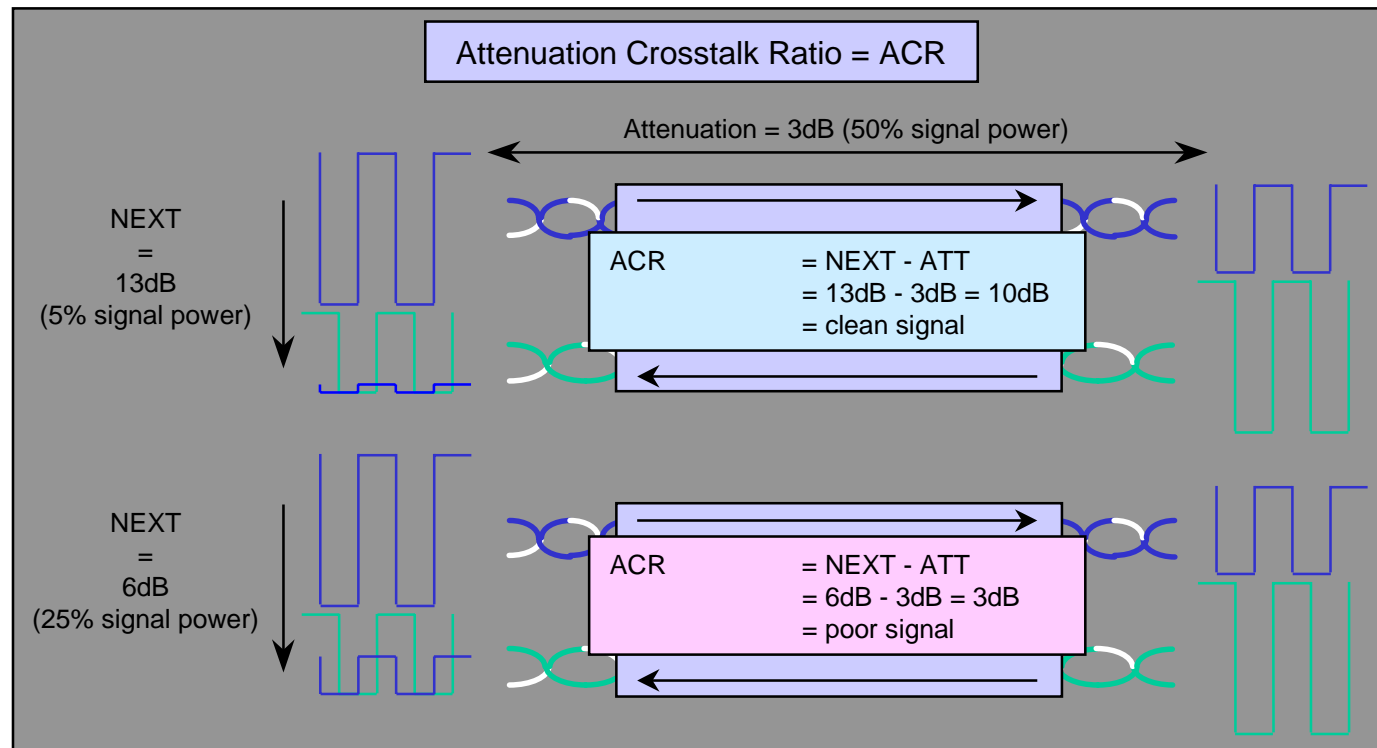


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Attenuation Crosstalk Ratio

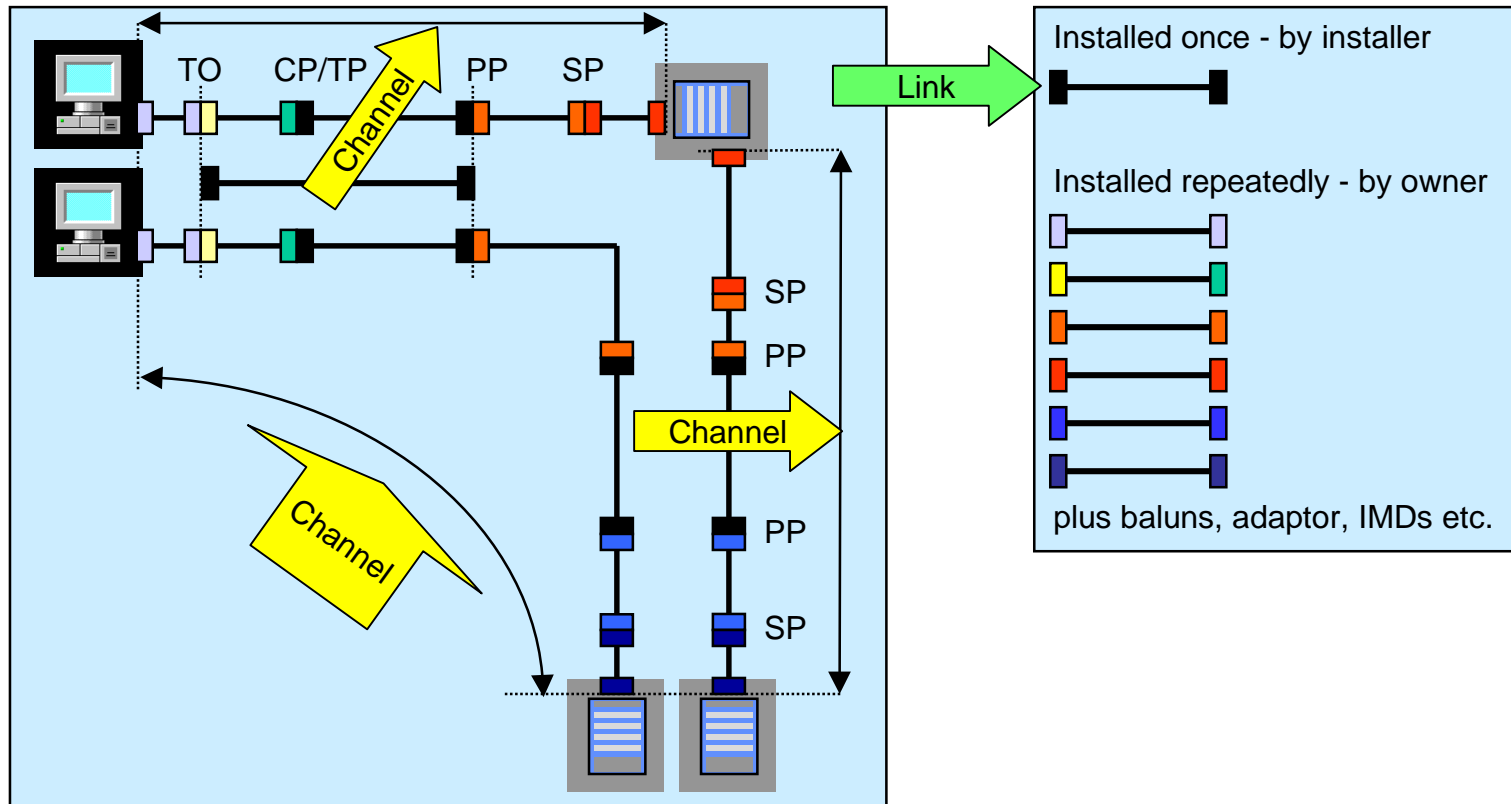


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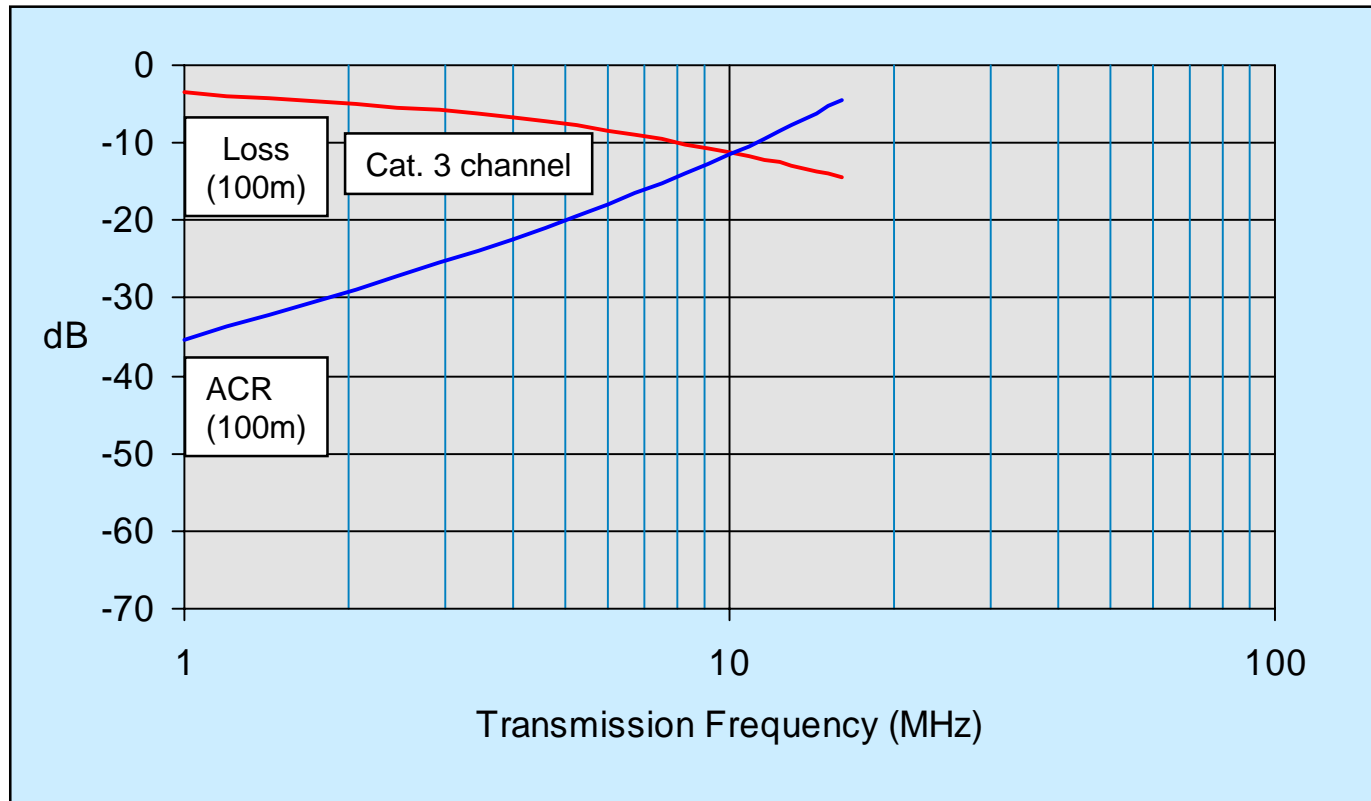
Links and Channels





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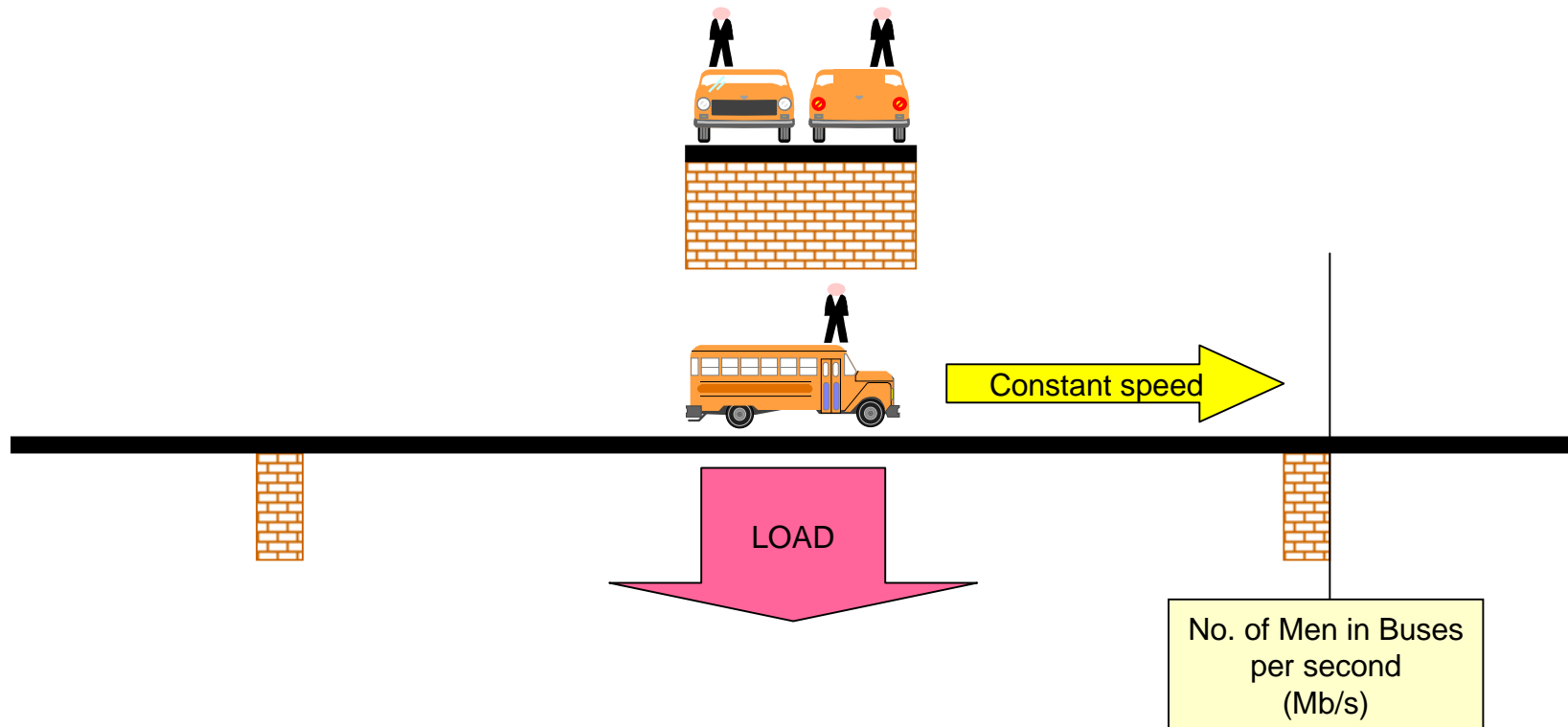
Cat. 3 Channel Performance





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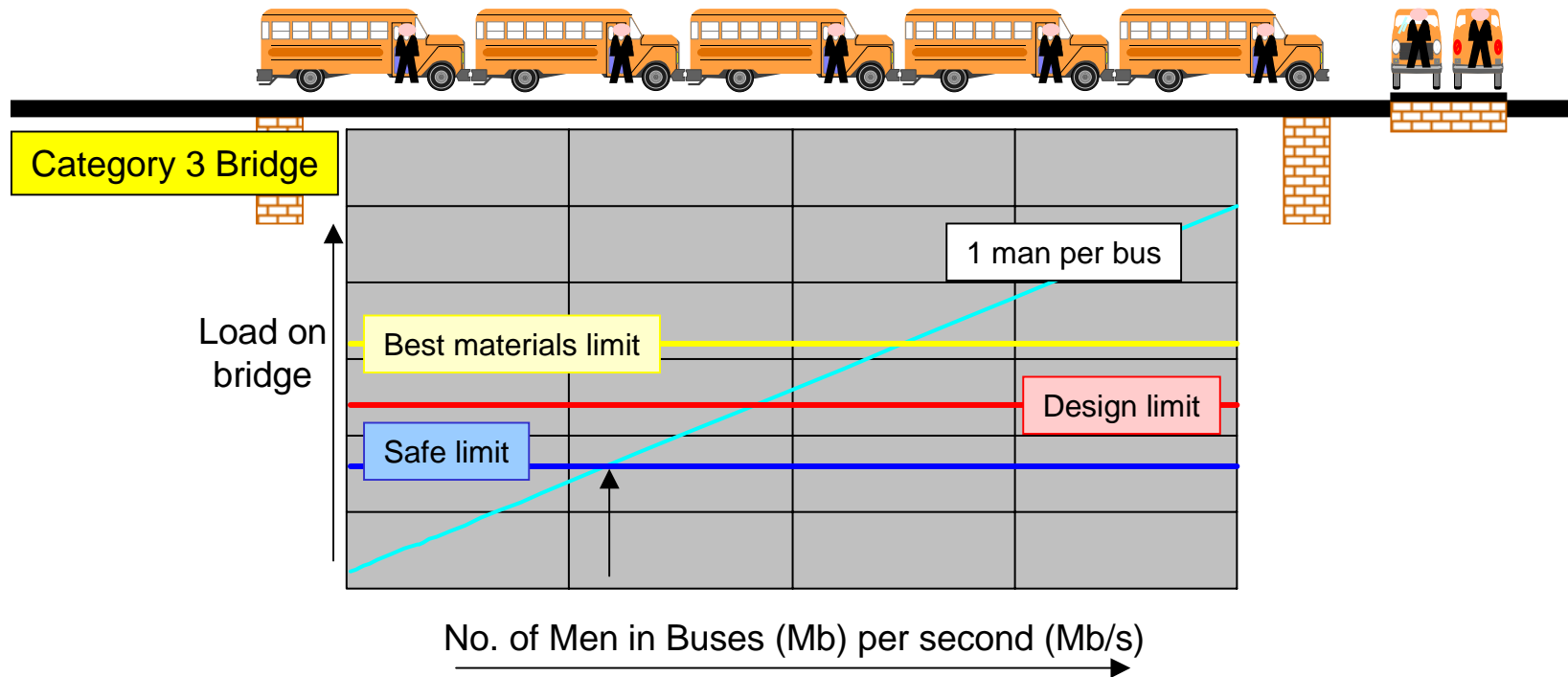
Bridges and Buses





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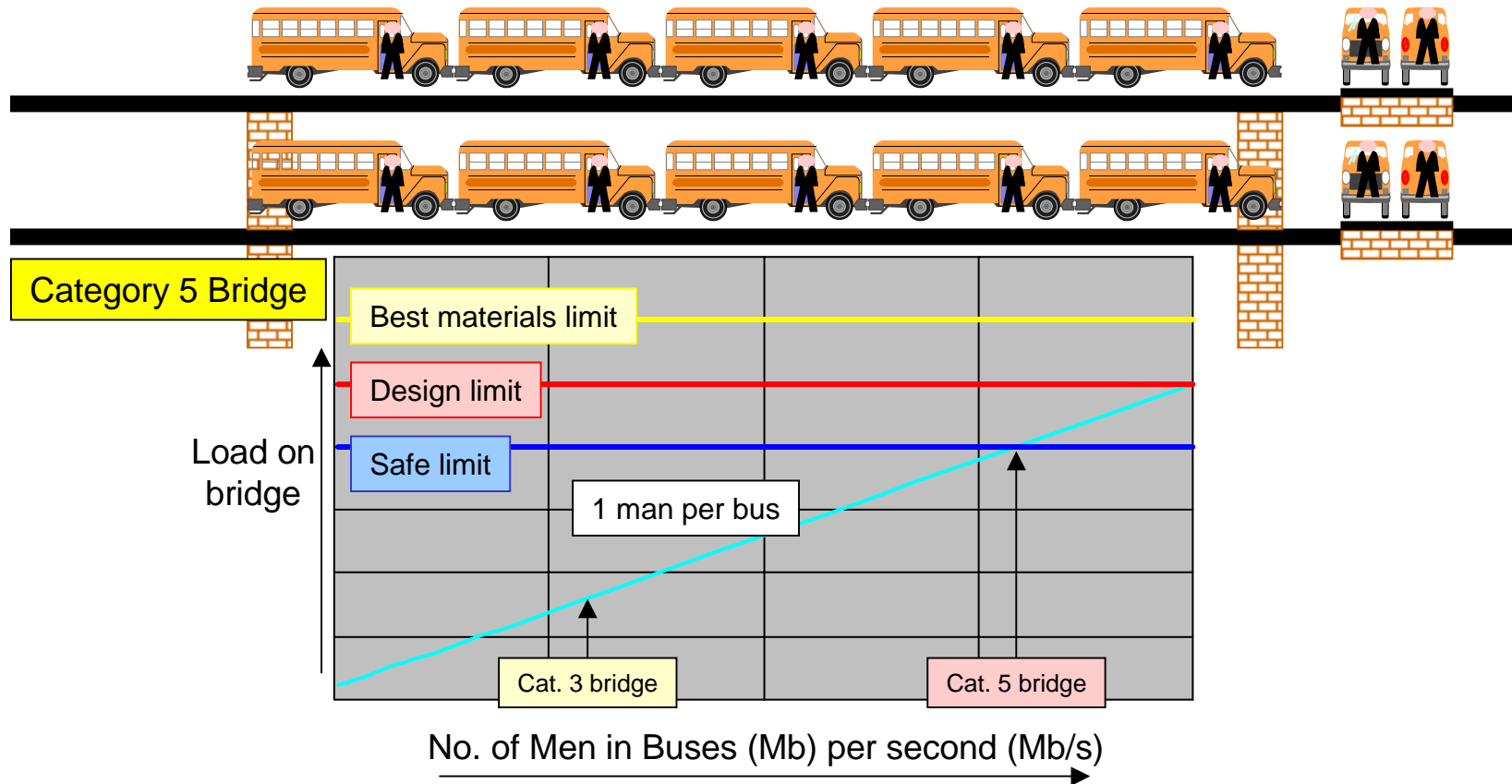
Early Network Evolution - I





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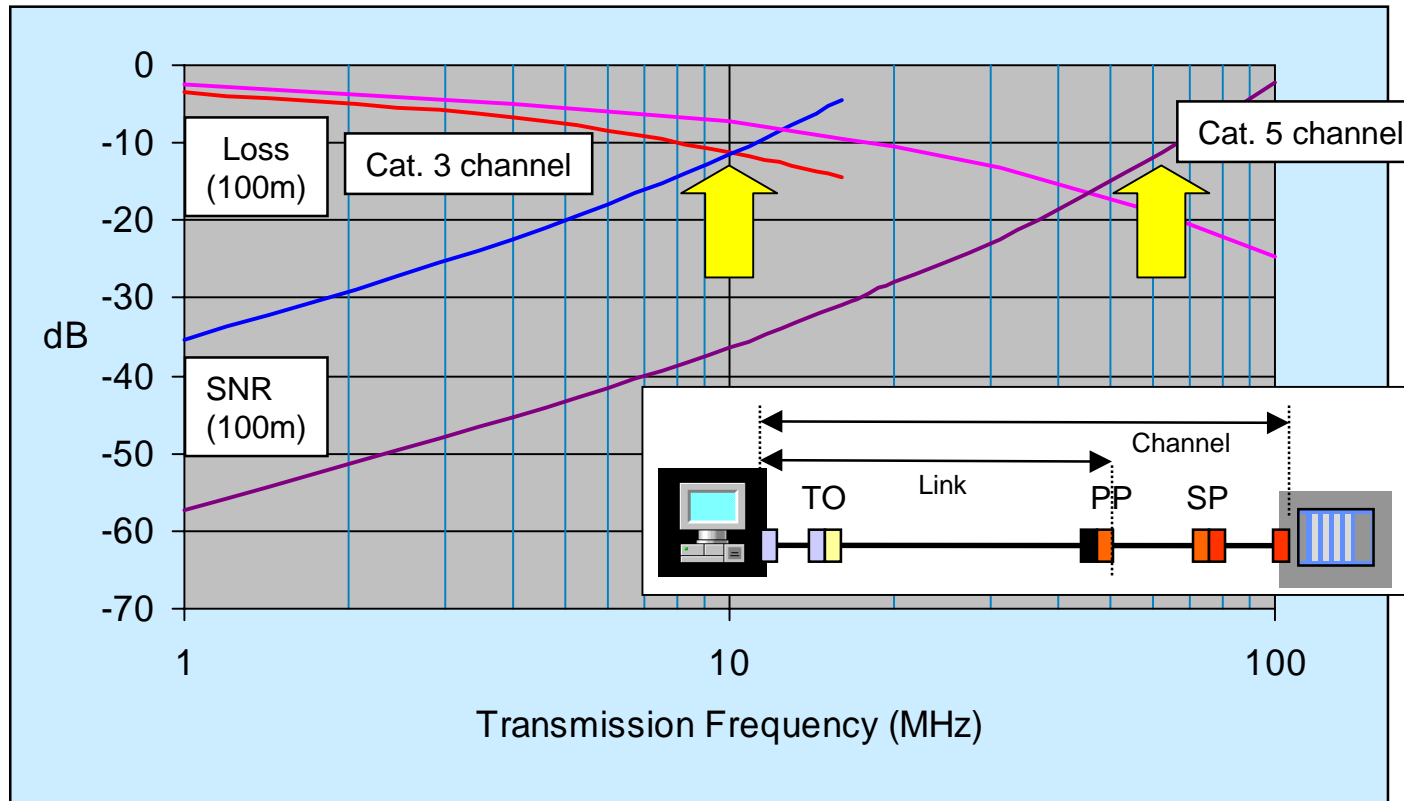
Early Network Evolution - II





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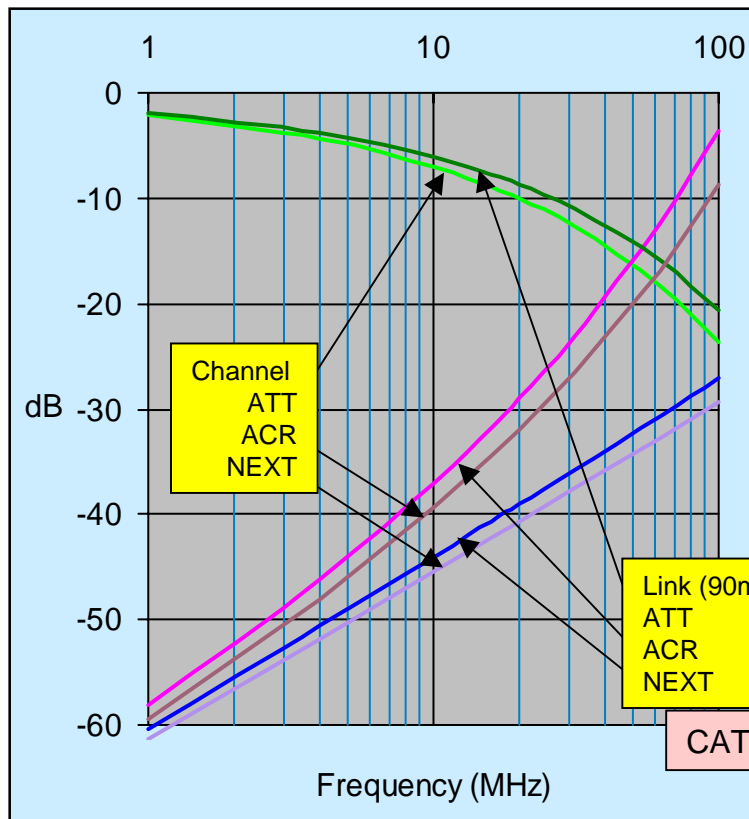
Cat. 5 Channel Performance



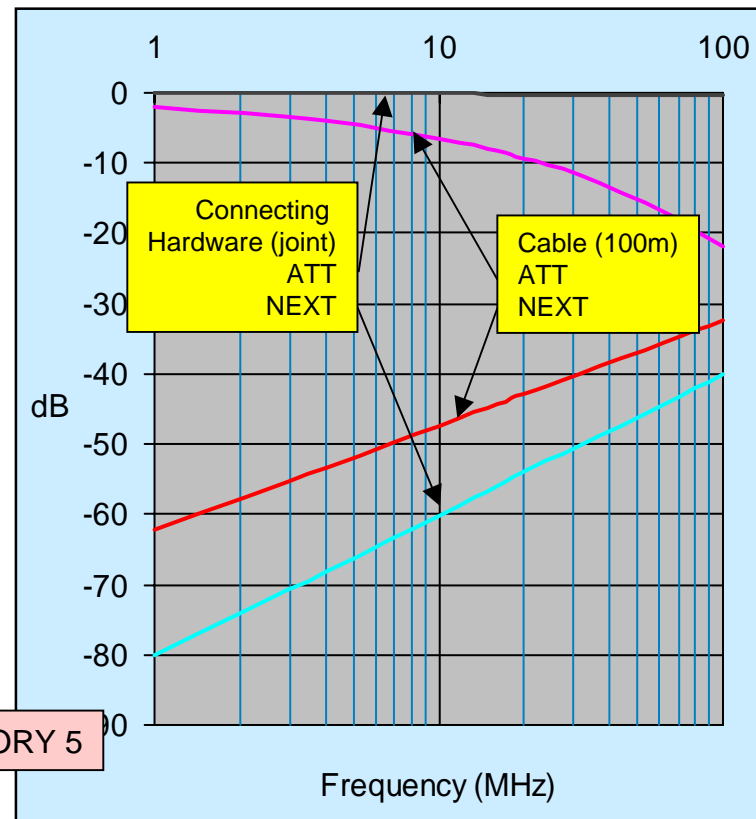


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Channel, Link and Product



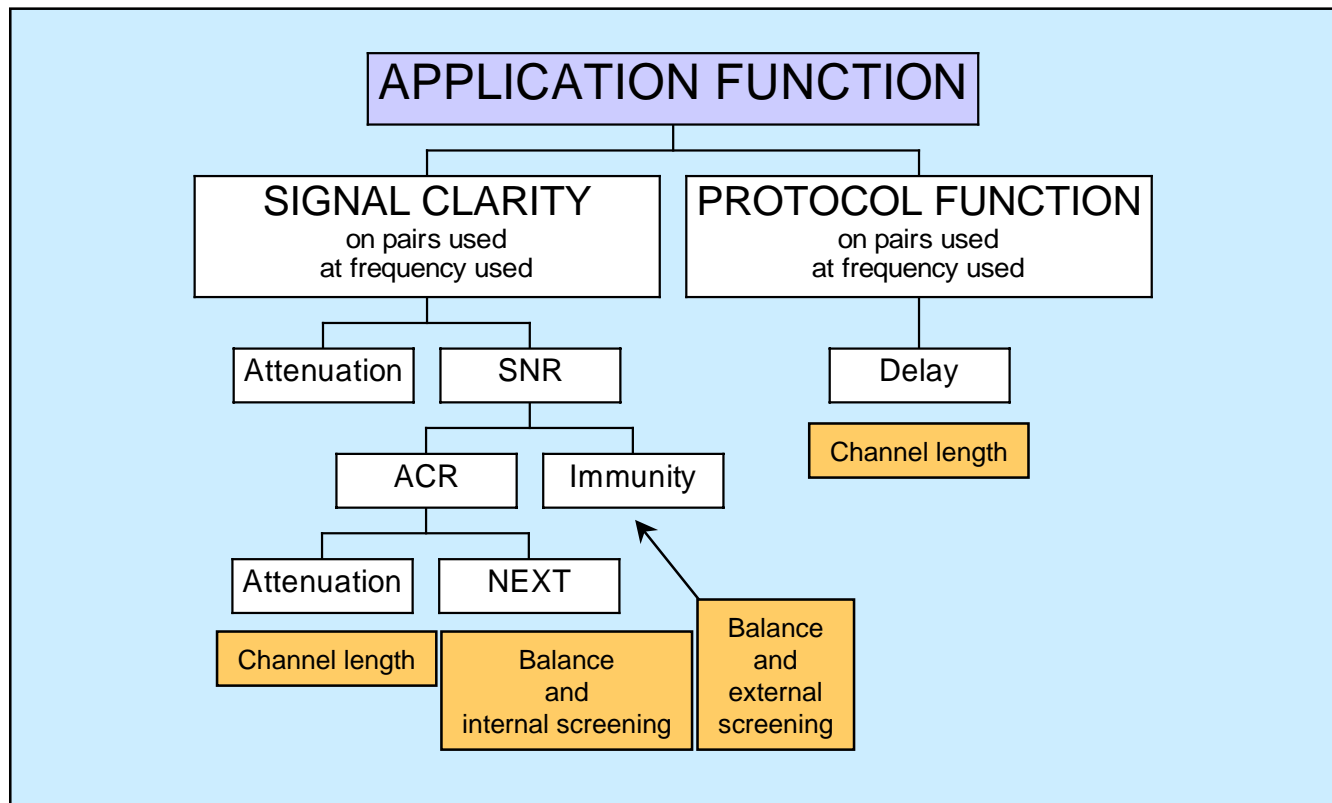
CATEGORY 5





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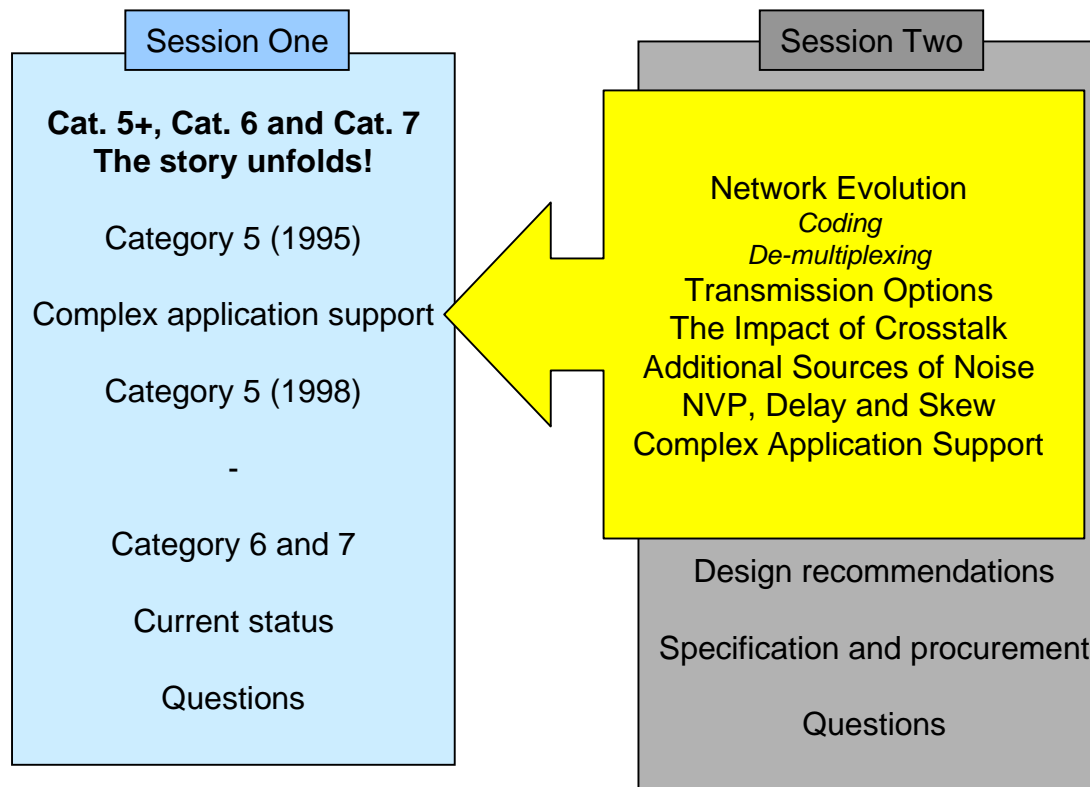
Application Support





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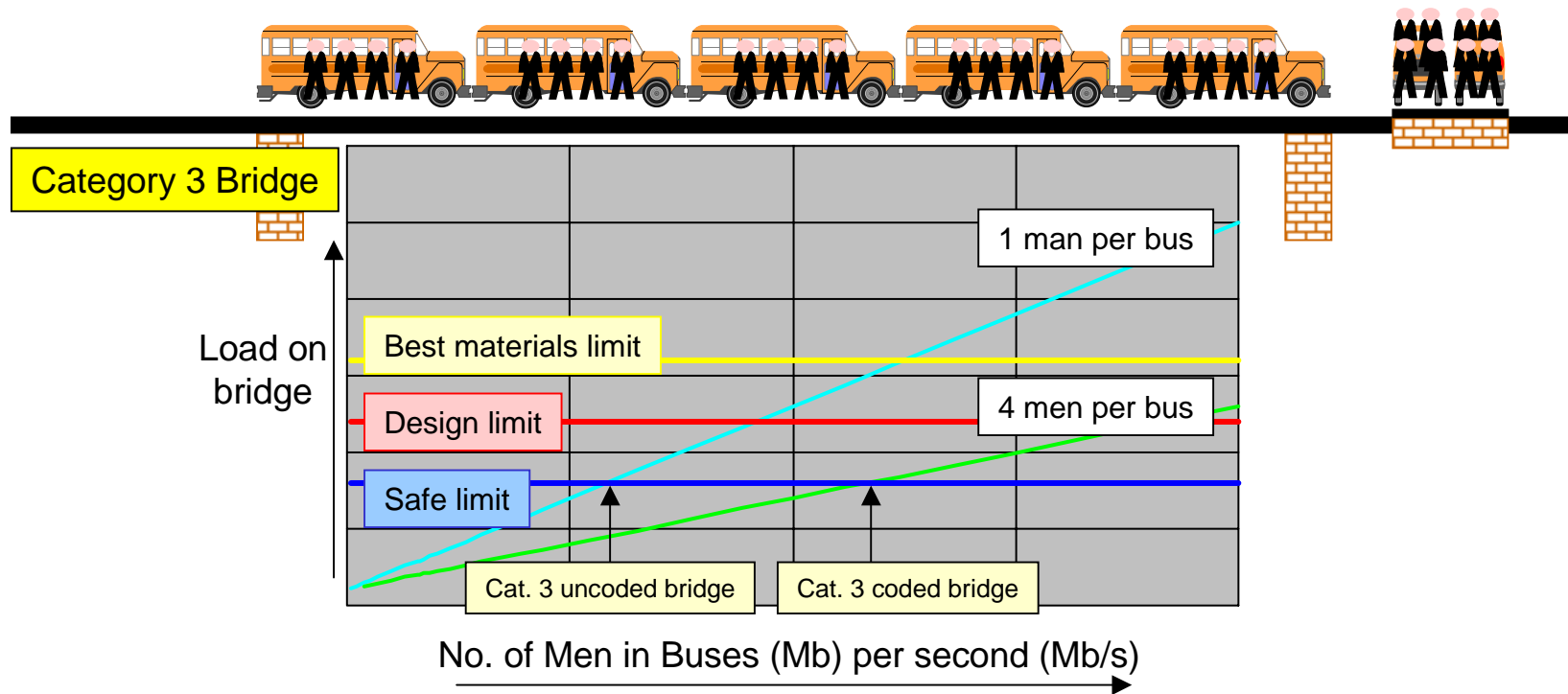
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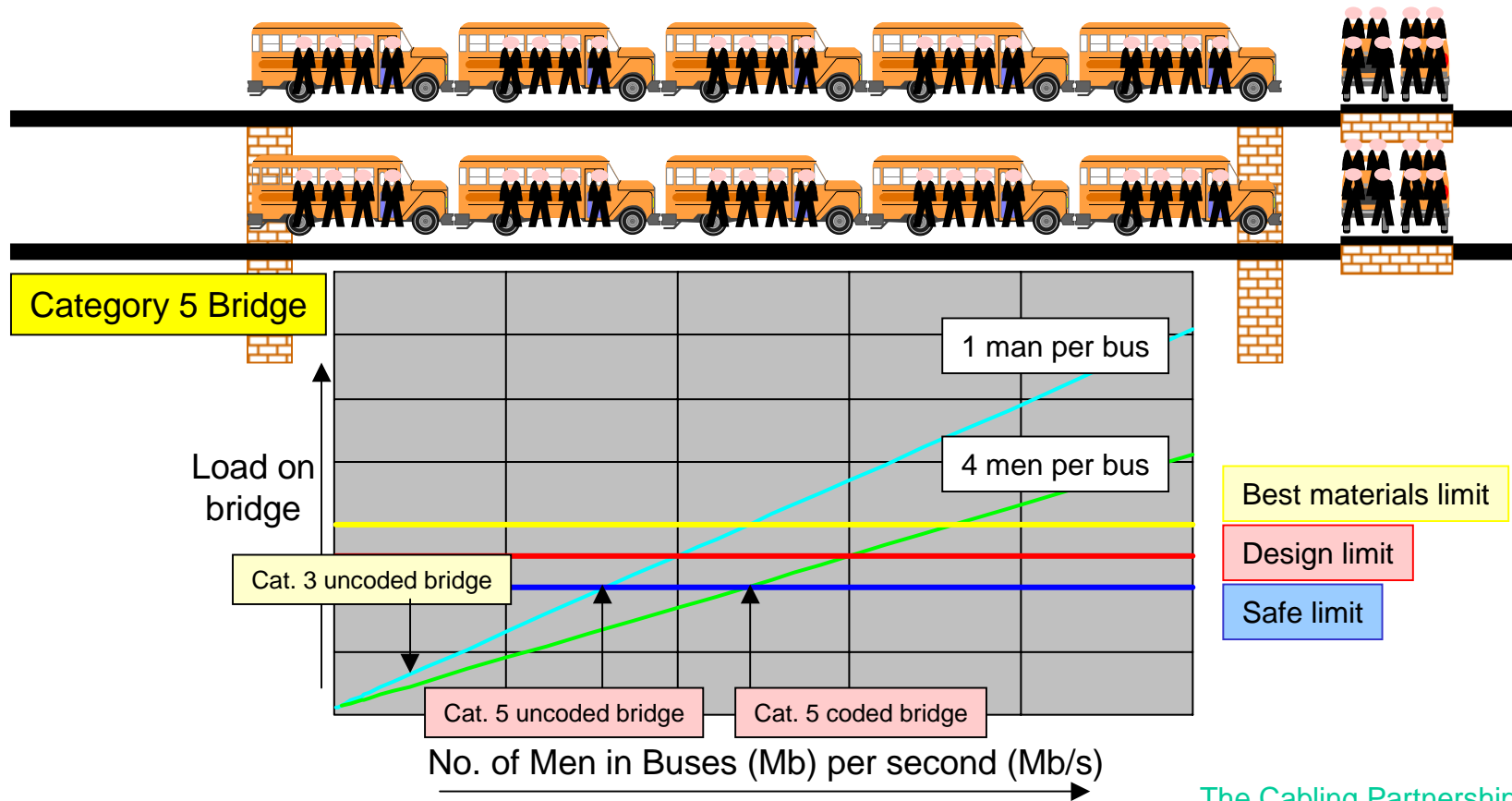
Network Evolution: Coding - I





DATA CABLING - BACK IN THE MELTING POT?

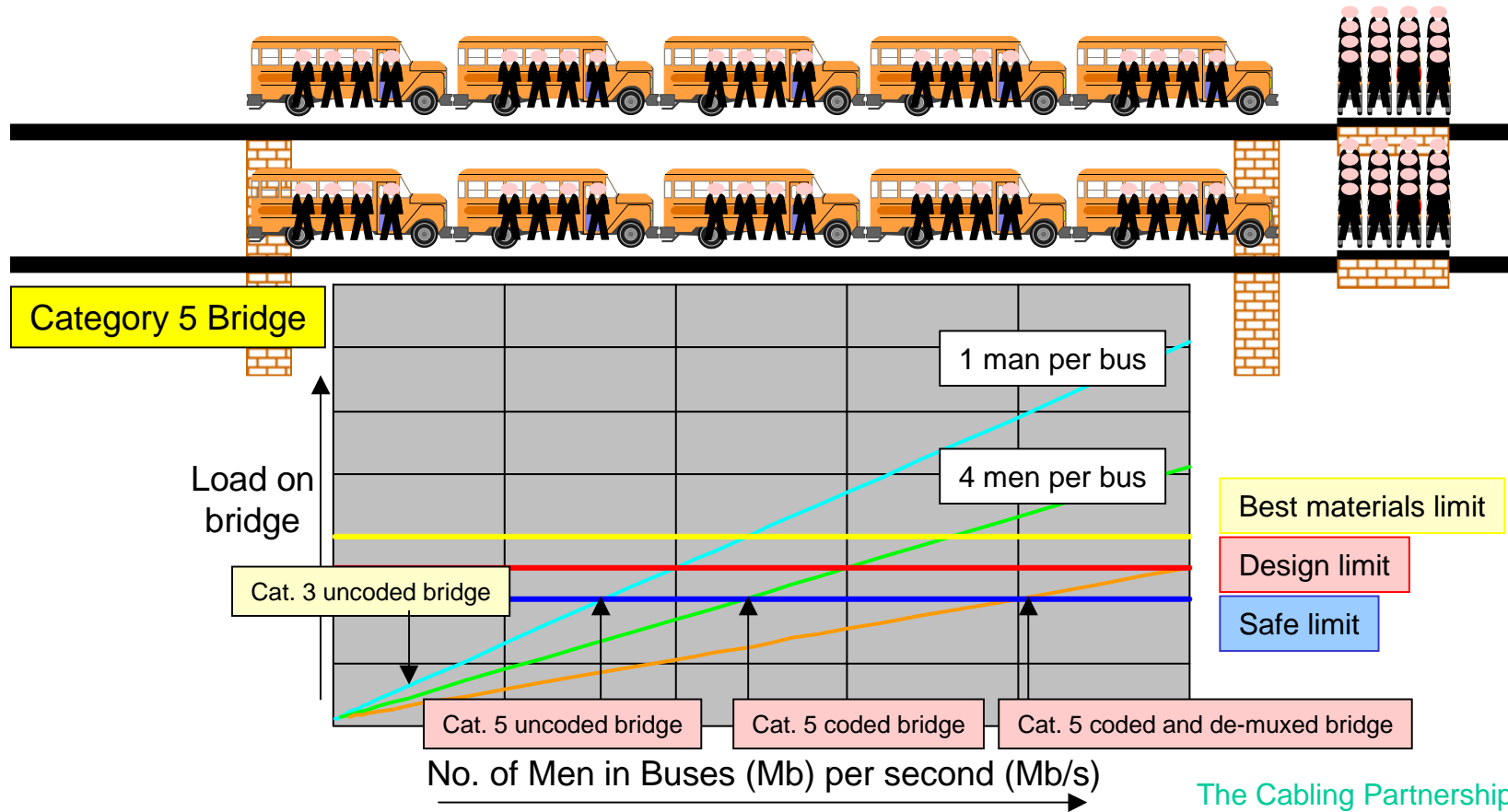
Network Evolution: Coding - II





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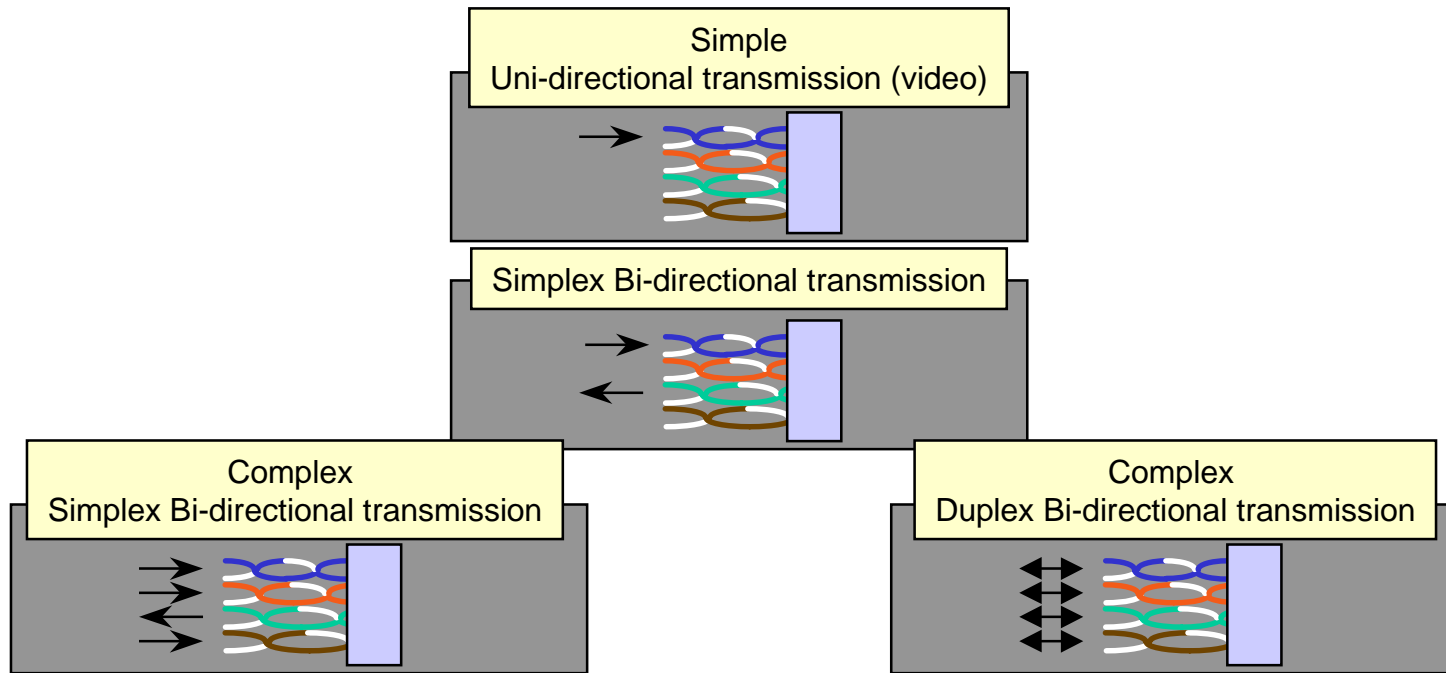
Network Evolution: De-mux





DATA CABLING - BACK IN THE MELTING POT?

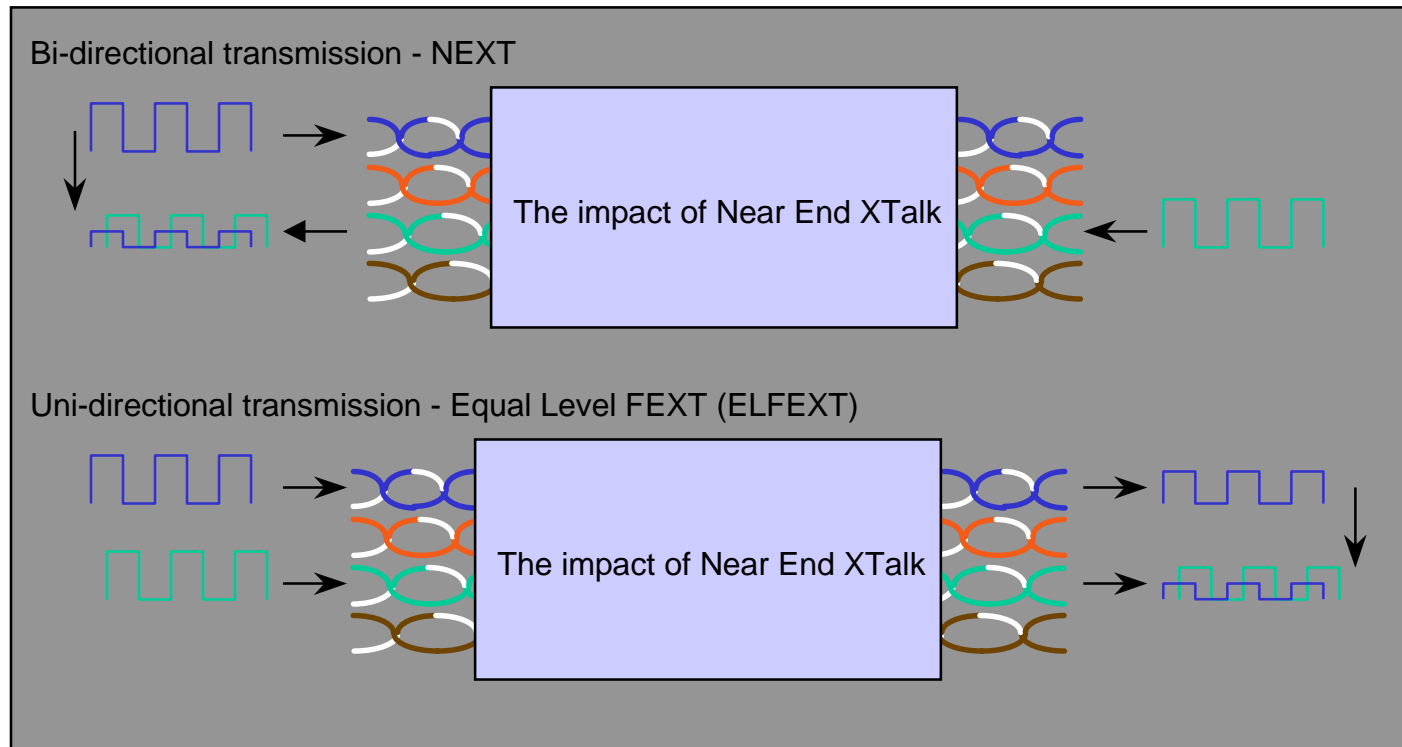
Transmission Options





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The Impact of Crosstalk - I

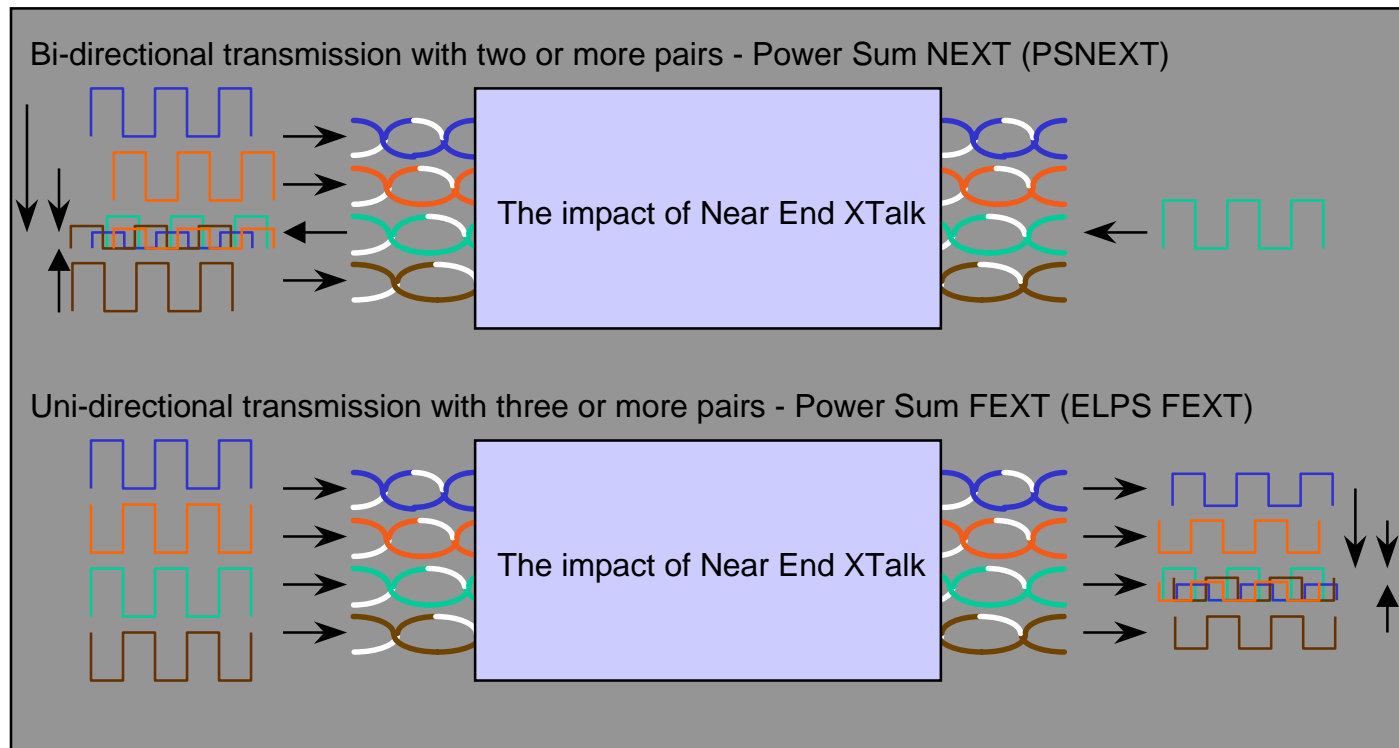


NOTE: transmissions over balanced pairs are not of square wave format



DATA CABLING - BACK IN THE MELTING POT?

The Impact of Crosstalk - II

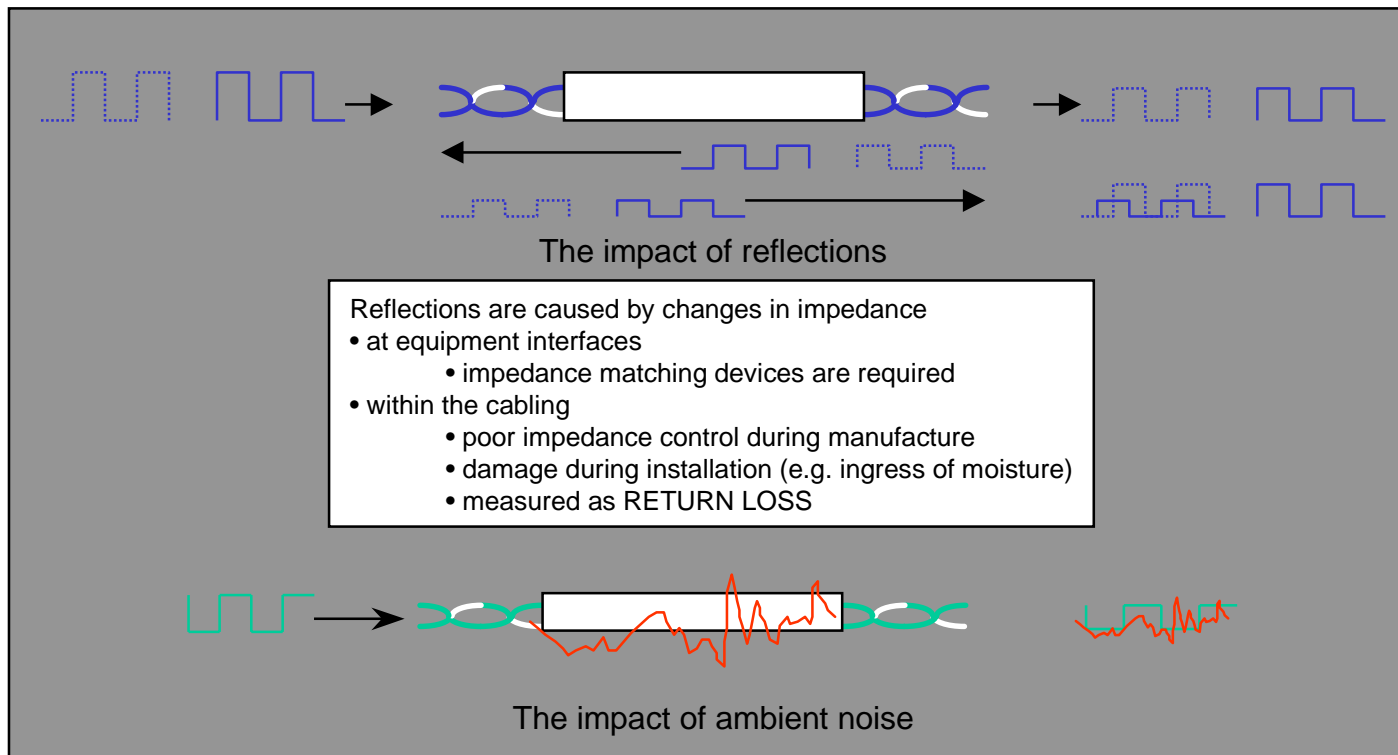


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Additional Noise Sources

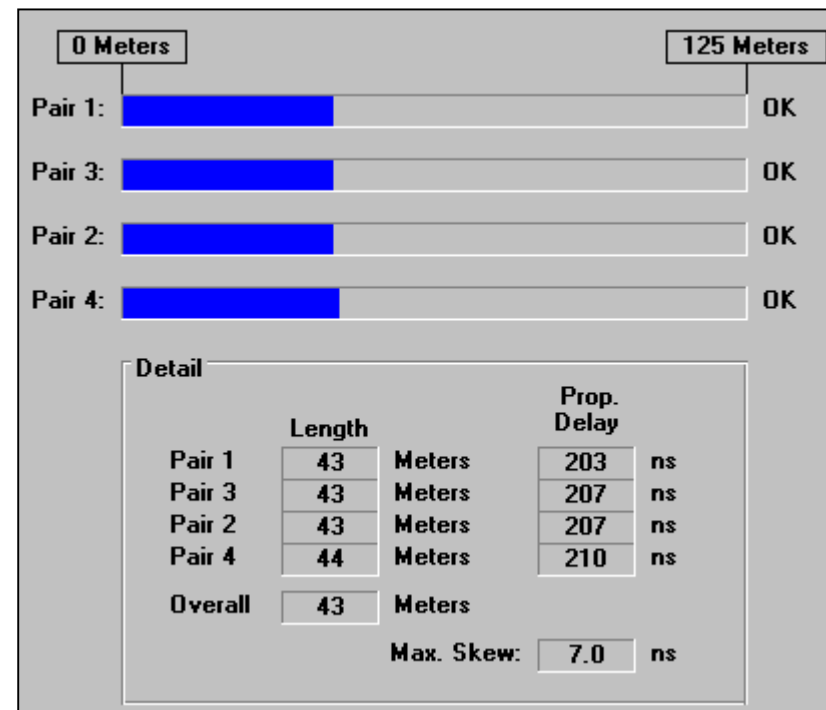




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NVP, Delay and Skew

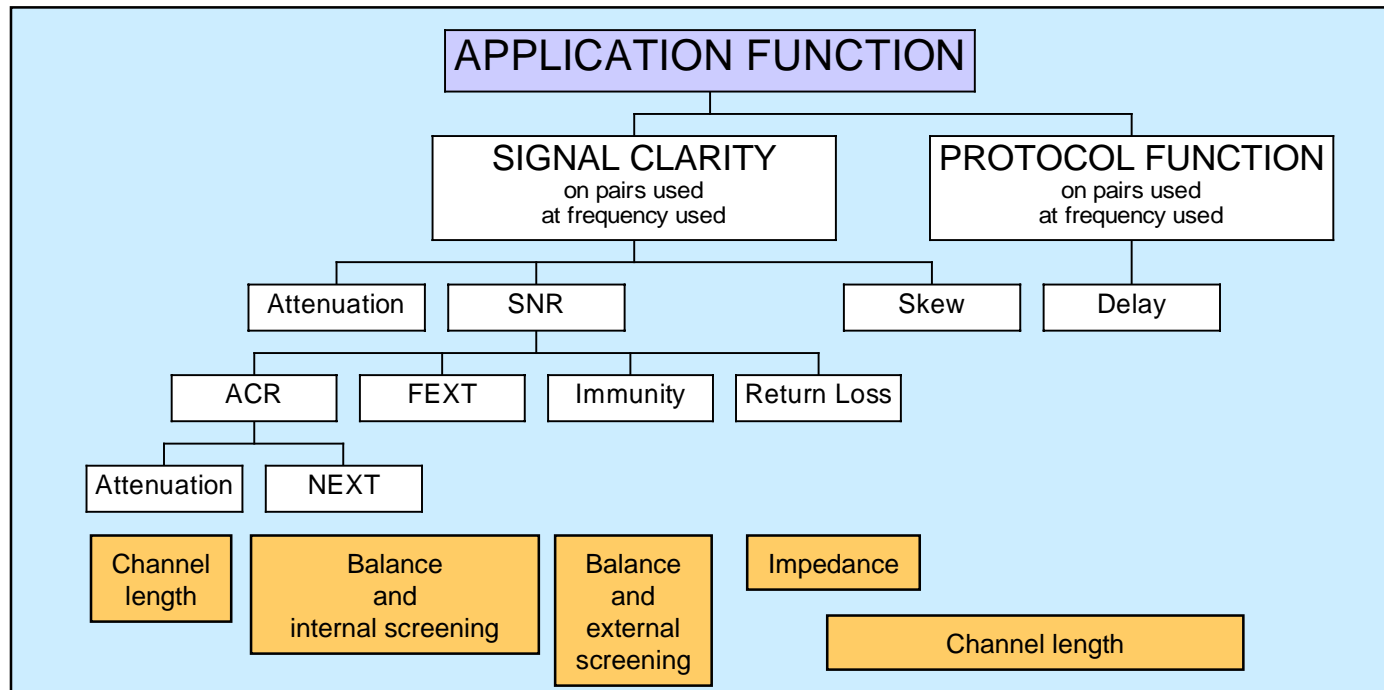
- NVP
 - nominal velocity of propagation
 - % of speed of light
- delay (uni- or bi-directional)
 - pairs lengths differ
 - due to twist lay length
 - all pairs longer than cable
 - due to overall lay
- skew
 - the difference in delay
 - fastest pair - slowest pair





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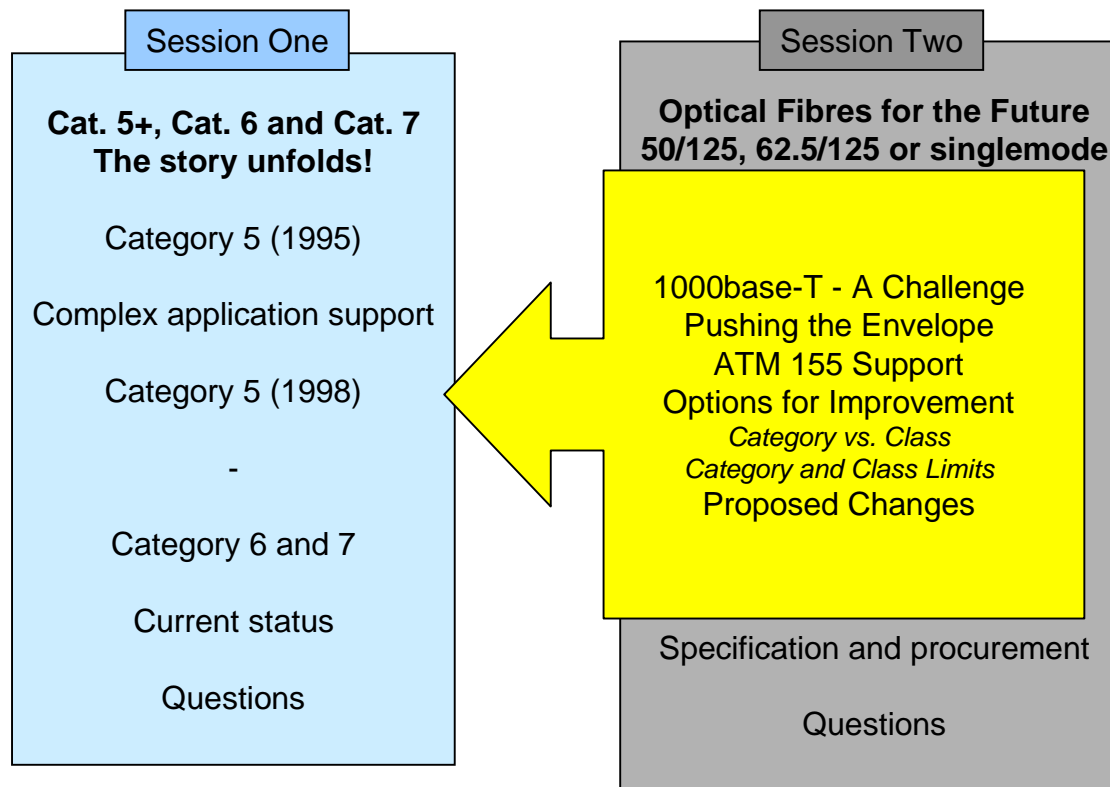
Complex Application Support





DATA CABLING - BACK IN THE MELTING POT?

Agenda





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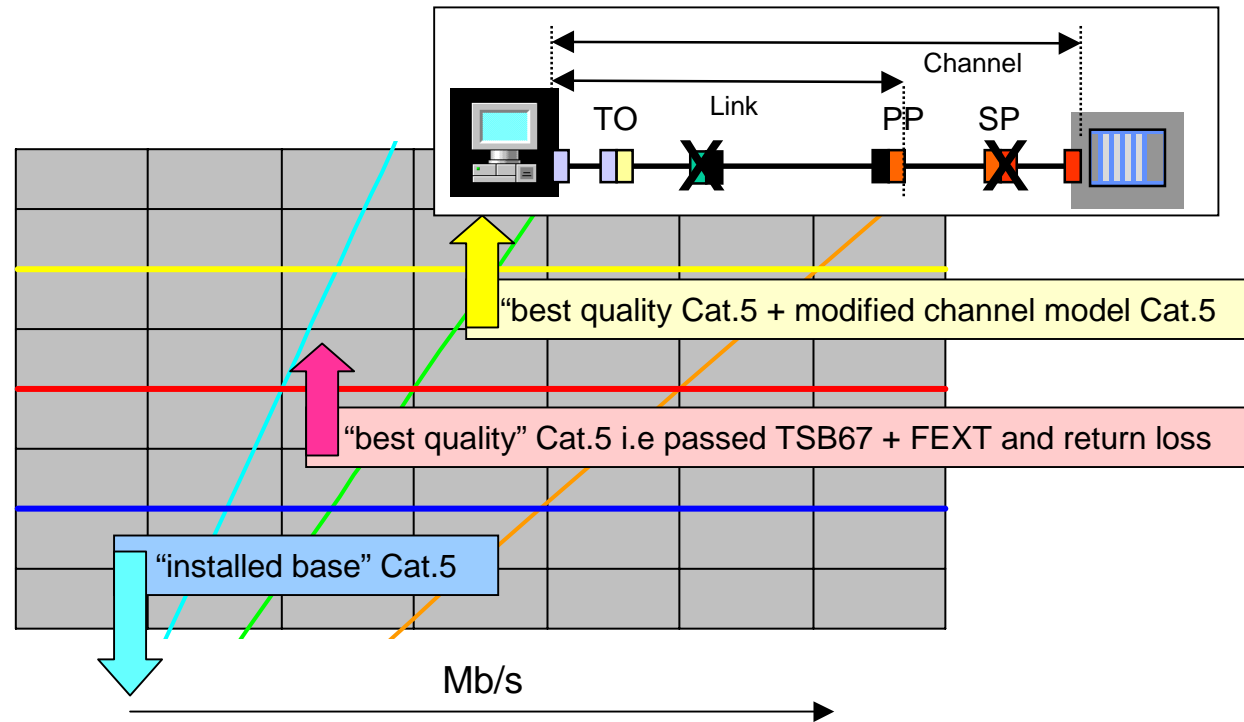
1000base-T - A Challenge

- 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
 - FEXT
 - return loss



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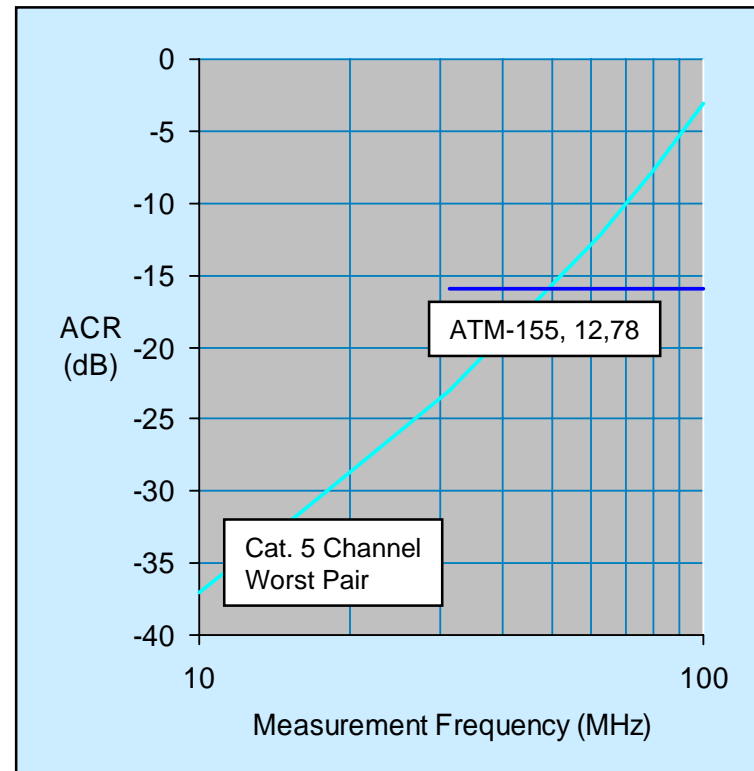
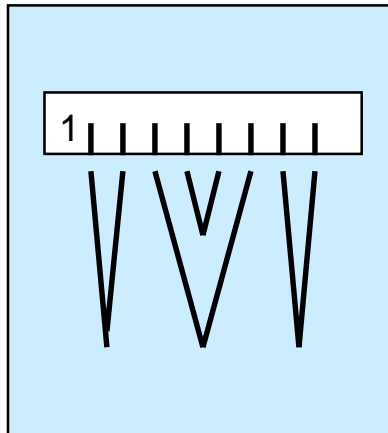
Pushing the Envelope





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ATM 155 Support





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Options for Improvement

- supplier pressure for new cabling specifications
- potential justification
 - possible shortfall in Cat. 5 channel ACR
 - preferred for ATM 155
 - unknown base of FEXT
 - required for 1000BaseT applications
- options
 - fully specified Cat.5
 - enhanced Cat. 5
 - new Categories



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Category vs. Class

IS 11801/EN 50173

- “Generic link” performance specification
- based upon application requirements
 - channel minus equipment cables
 - length independent
- four classes
 - < 100kHz
 - < 1MHz
 - < 16MHz
 - < 100MHz

ANSI/TIA/EIA 568A/TSB67

- “Basic link” performance specification
- based upon
 - component performance
 - 90 metre template
- three Categories
 - Category 3 < 16MHz
 - Category 4 < 20MHz
 - Category 5 < 100MHz

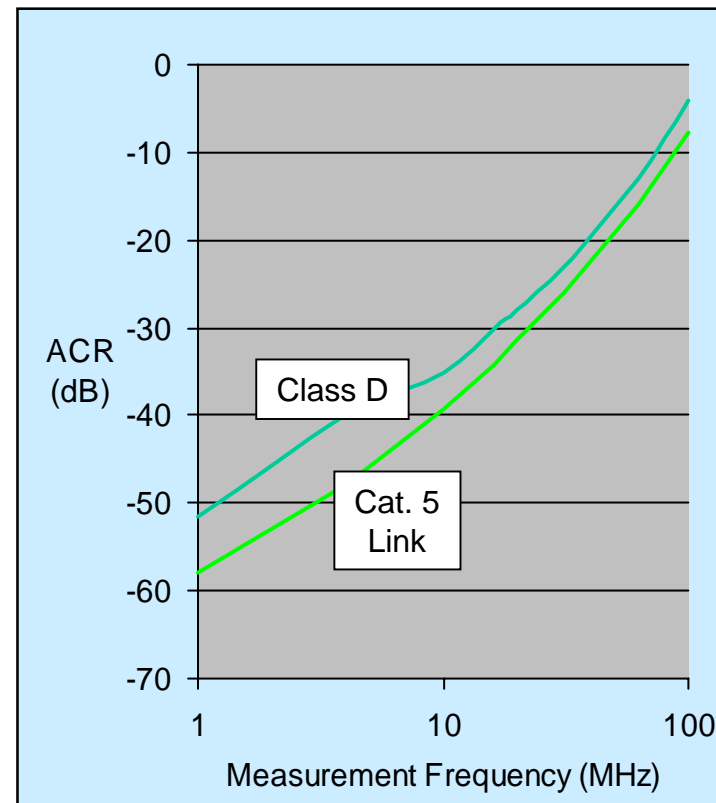
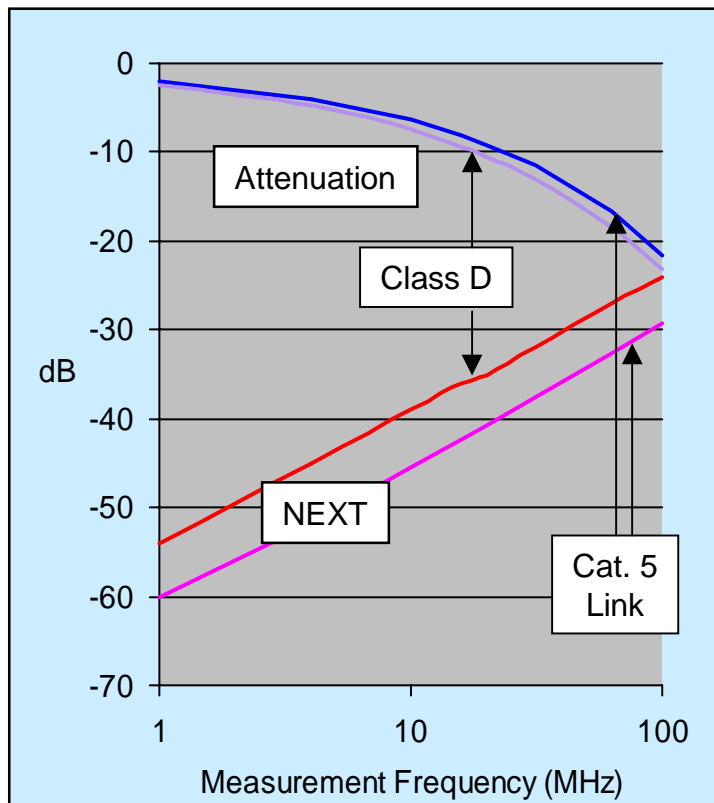
CATEGORY AND CLASS ARE NOT EQUIVALENT

- 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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Proposed Changes

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

Revision 2001?
ANSI/TIA/EIA 568B



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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
 - Category 3 implementation
- extra parameters included
 - Return loss
 - PowerSum NEXT
 - ELFEXT
 - PowerSum ELFEXT
 - Delay/Skew

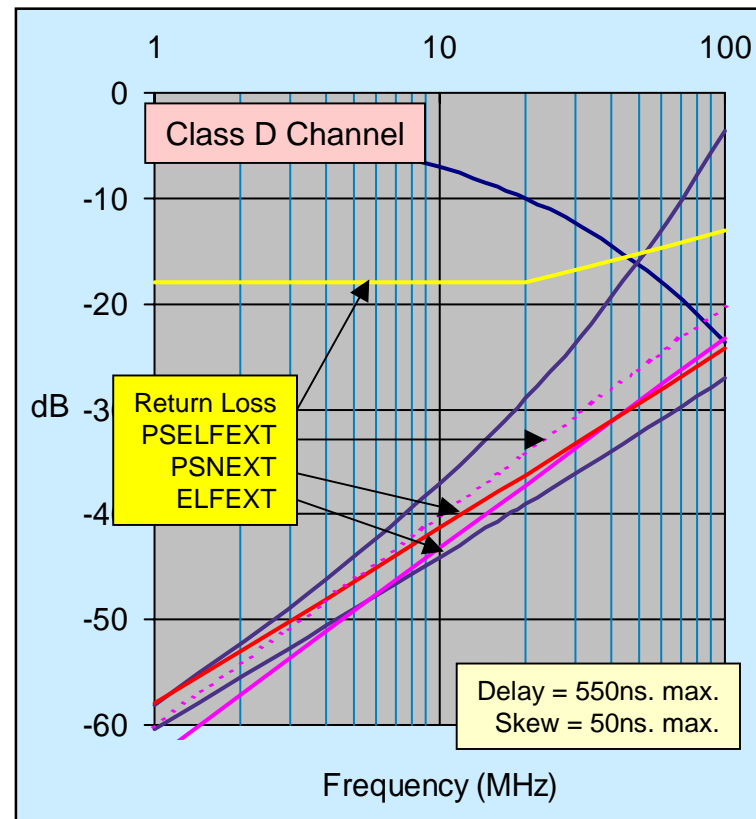
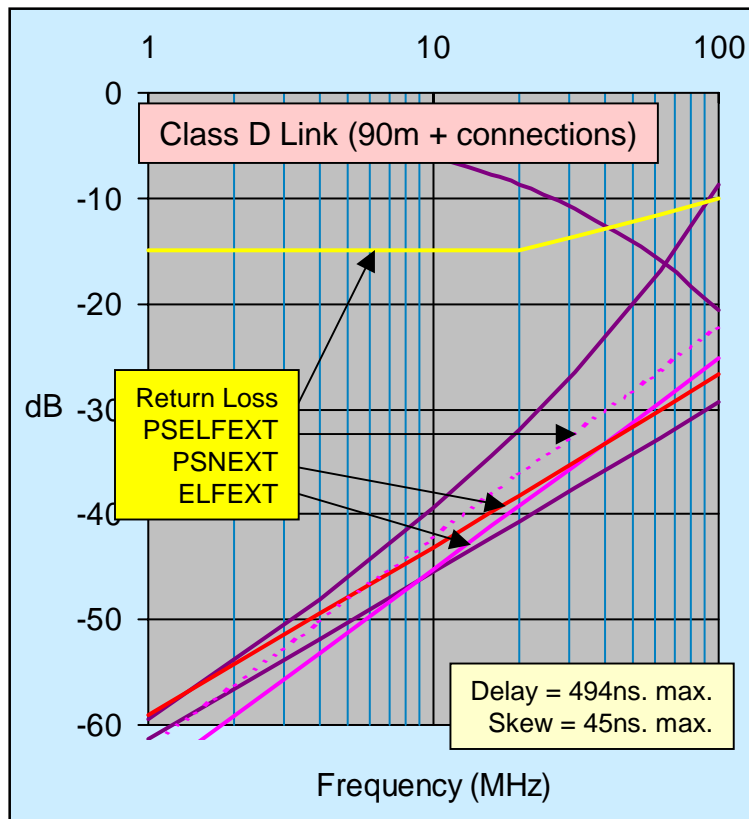
THE BRIDGE HAS REACHED ITS DESIGN LIMIT

- much of installed base fails to meet “safe limit (1995)”
- a greater proportion will fail to meet “design limit (1998)”



DATA CABLING - BACK IN THE MELTING POT?

EN50173 (1998): Amndmt - II





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Cat. 5+, Cat. 6 and Cat. 7
The story unfolds!

Category 5 (1995)

Complex application support

Category 5 (1998)

Break

Category 6 and 7

Current status

Questions

Session Two

Optical Fibres for the Future
50/125, 62.5/125 or singlemode

Cabling performance

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Design recommendations

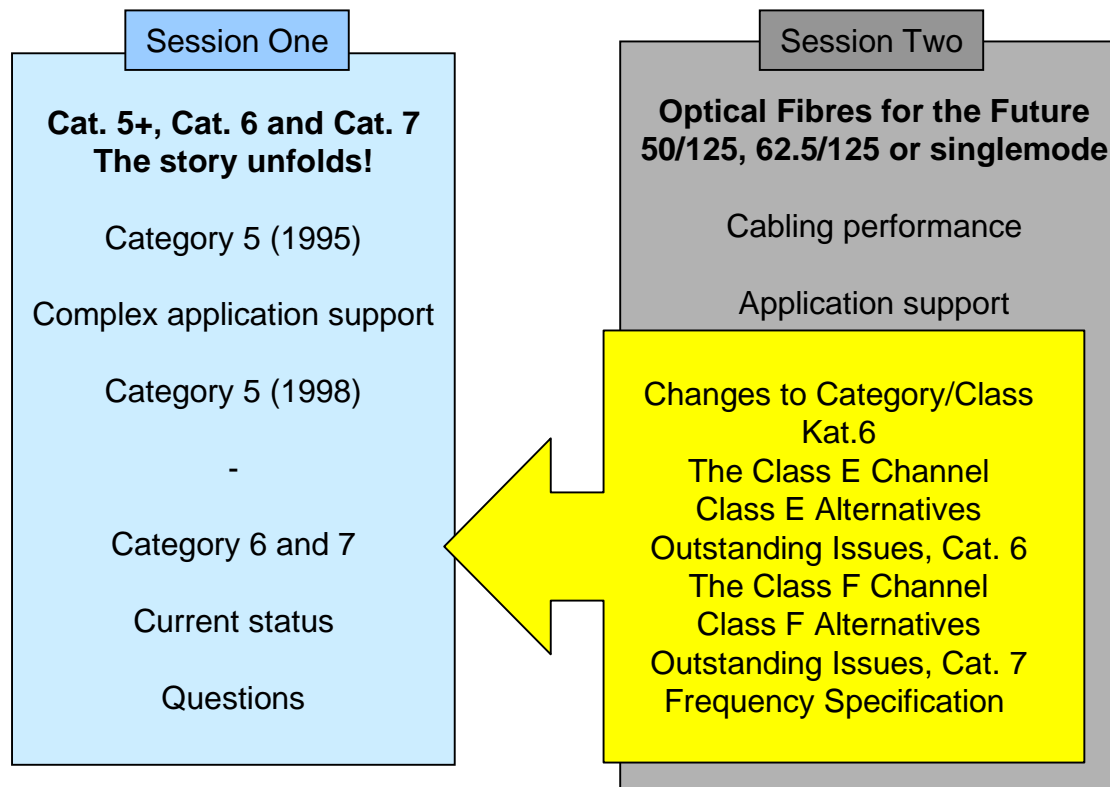
Specification and procurement

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Agenda





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Changes to Category/Class

- Removal of Category 3 (but not Class C) - probable
- Removal of 150Ω - probable

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

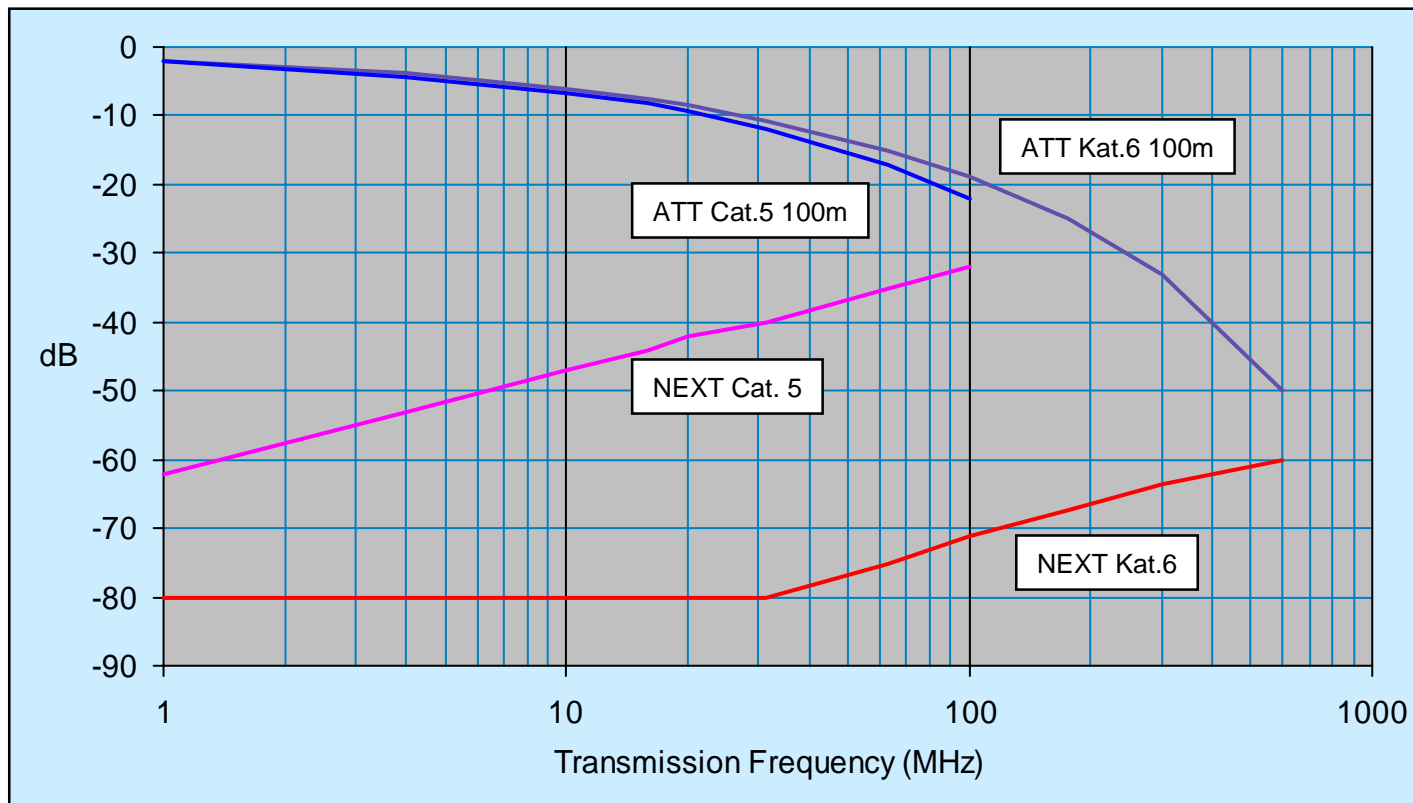
- Class F - Category 7
 - positive PSACR at 600MHz
 - supported over
 - individually screened balanced pair
 - new connector

- Backwards compatibility
 - lower Class applications
 - 4 pair solution



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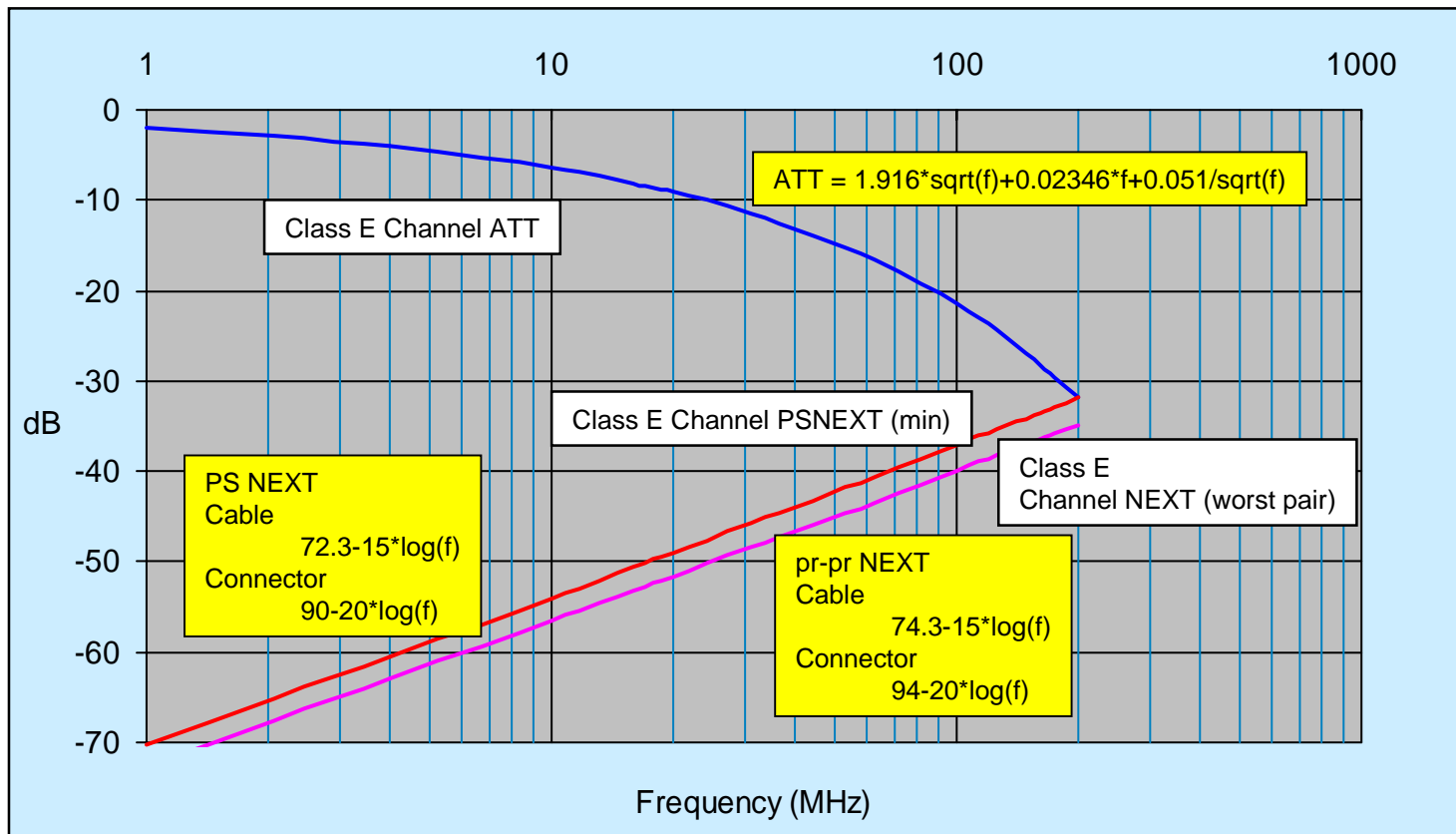
German ~~Kat. 6~~ Cat. 7 Cable





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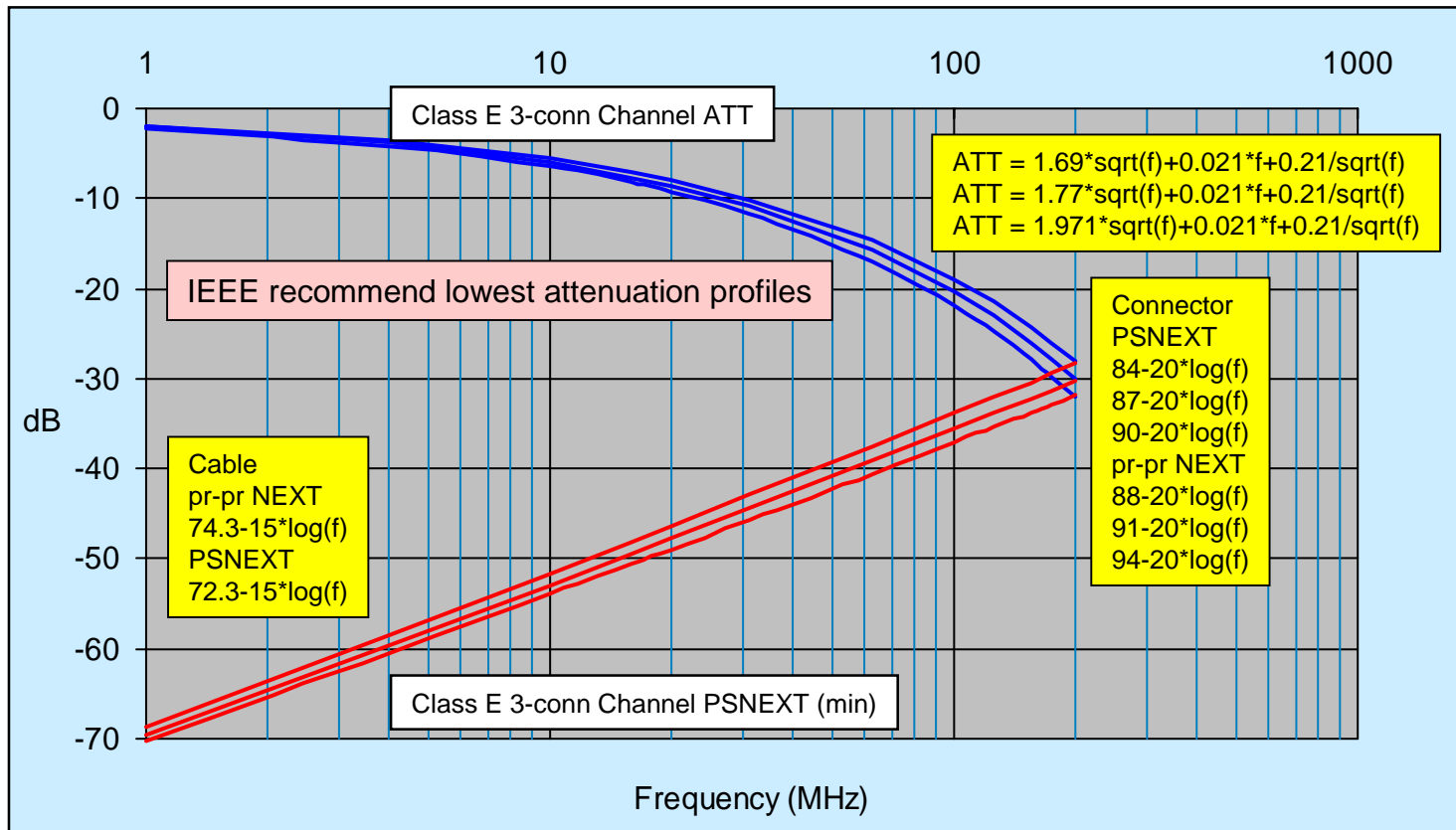
“Class E” Channel (Munich)





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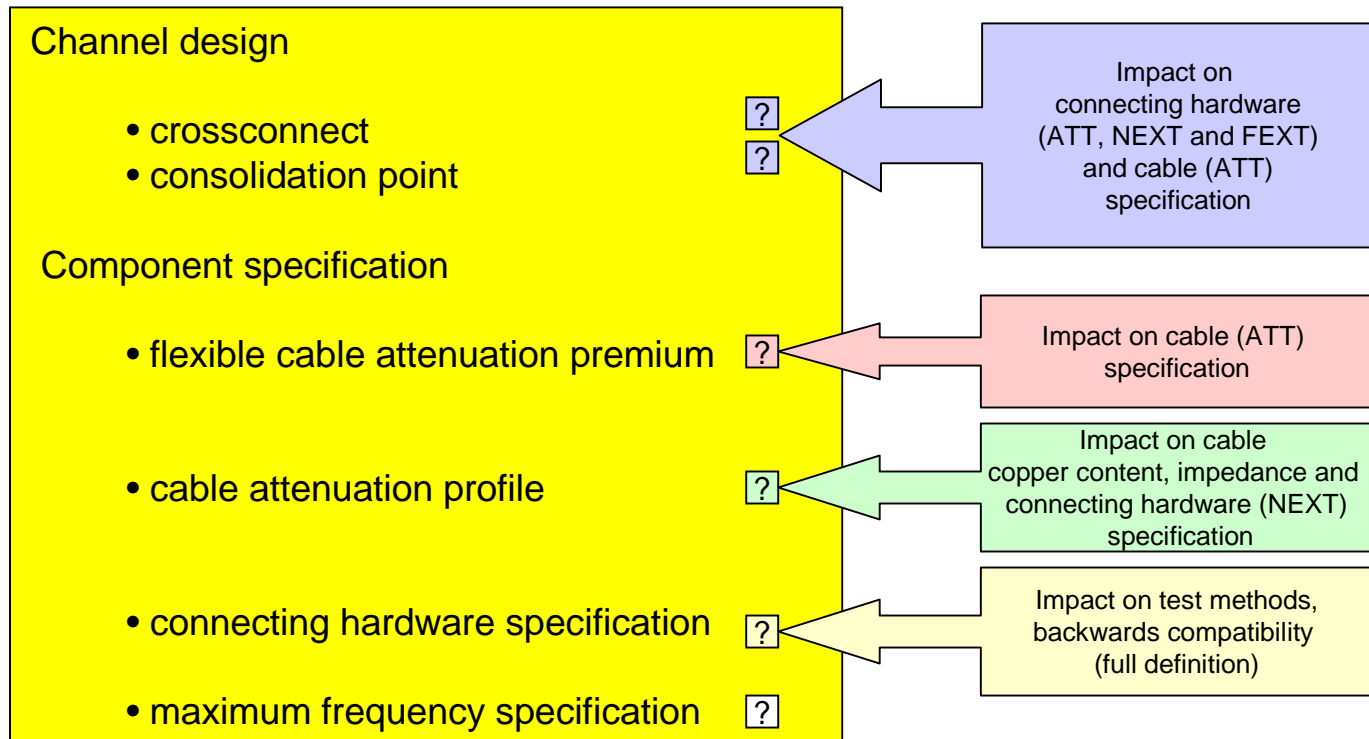
Class E Alternatives





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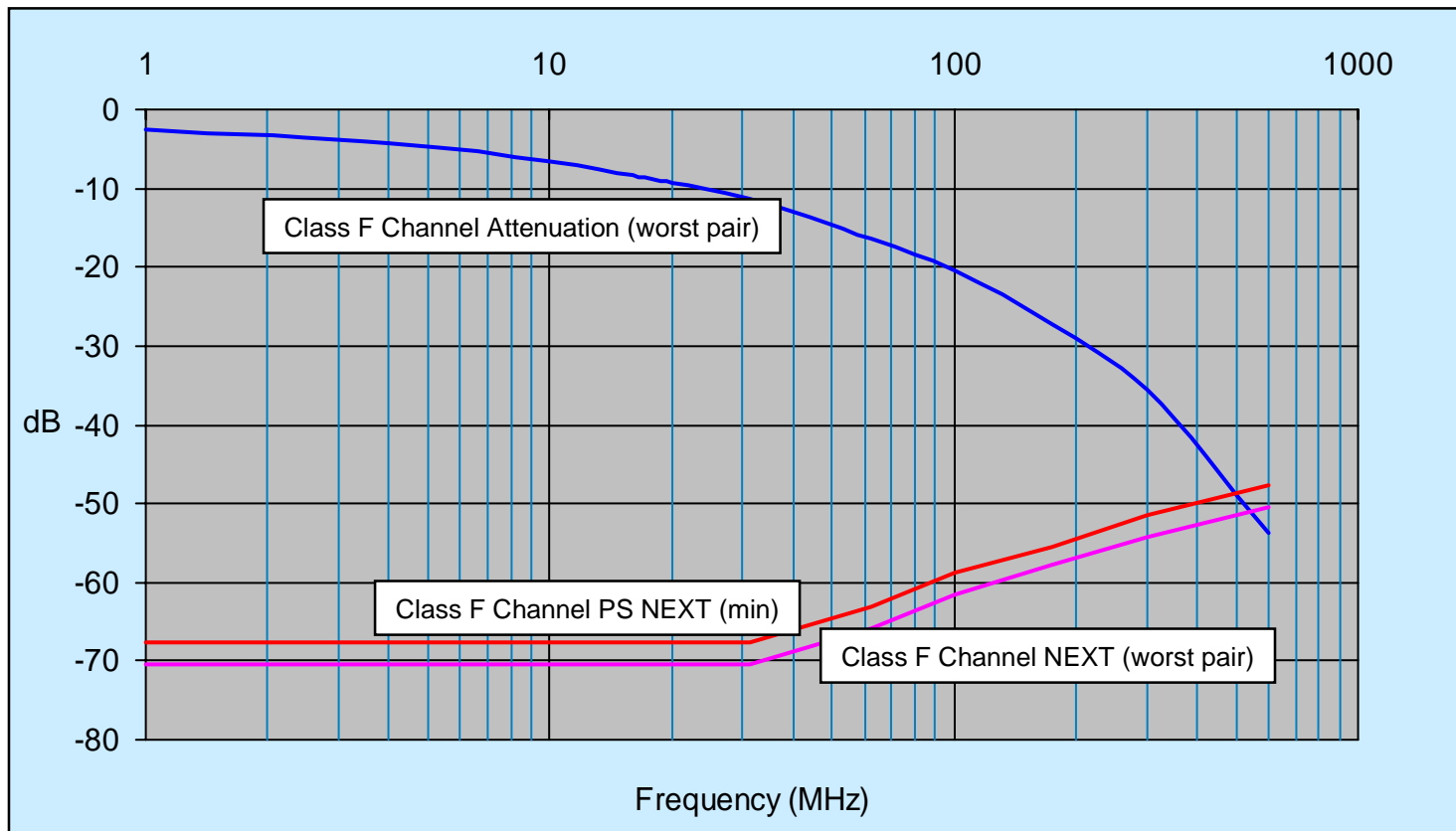
Outstanding Issues, Cat. 6





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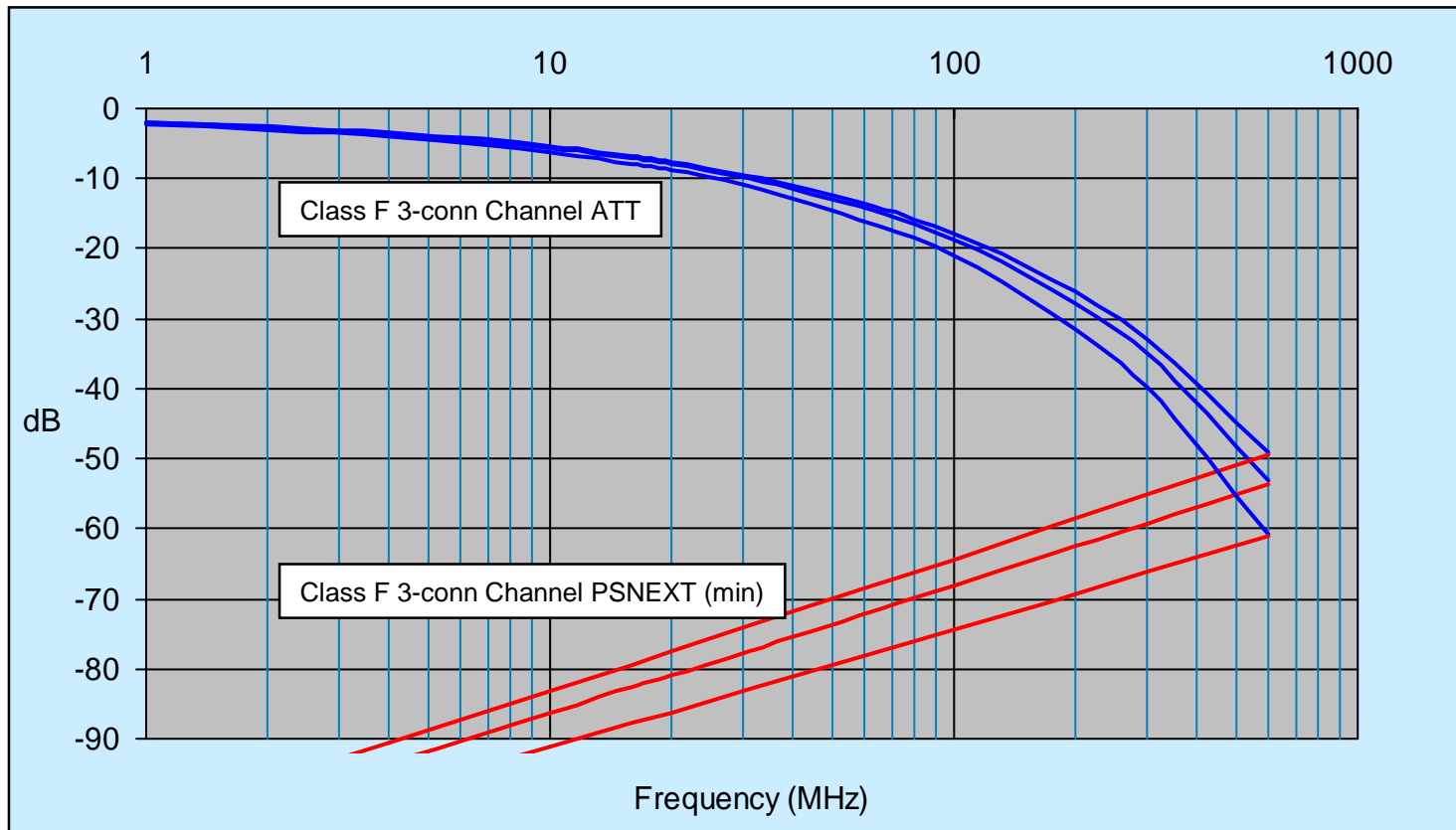
~~“Class E”~~ Class F DIN Pre-S





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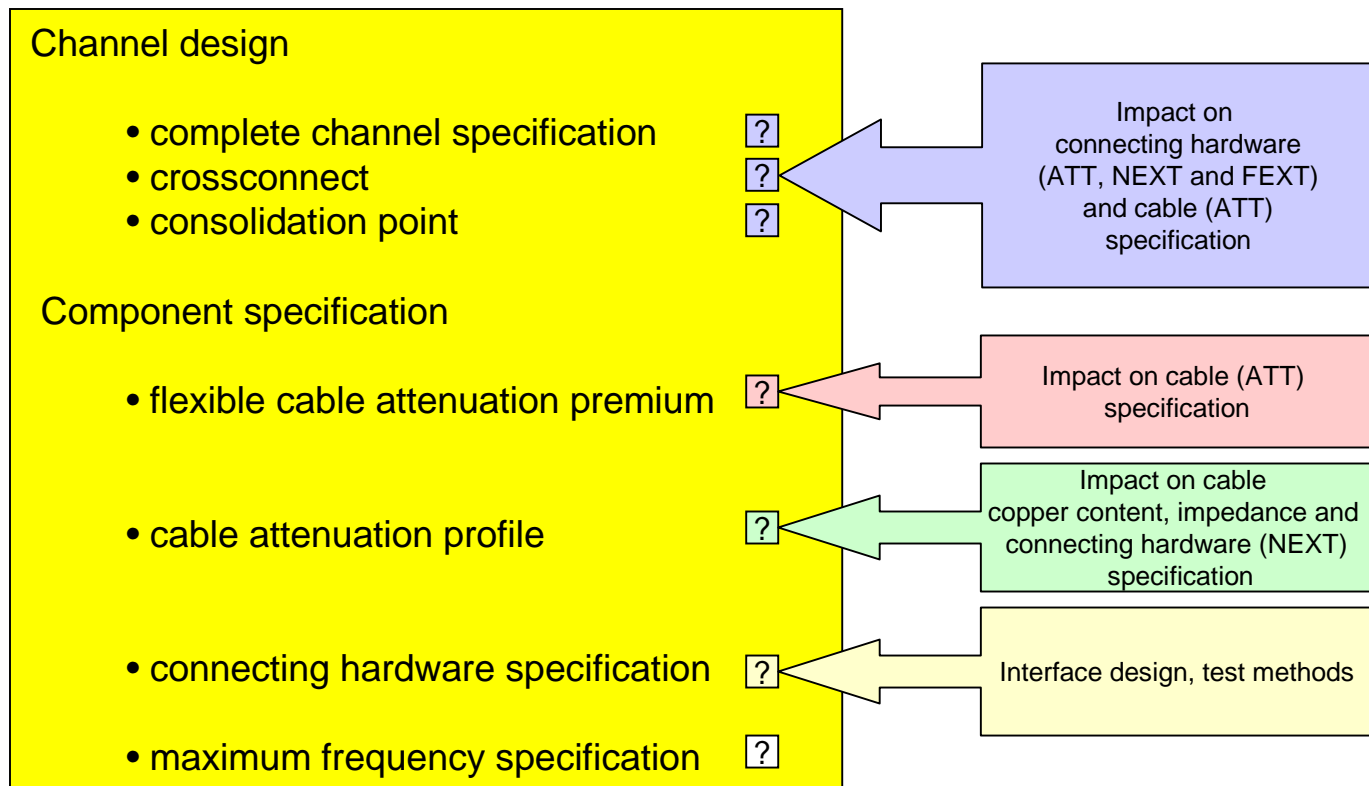
Class F Alternatives





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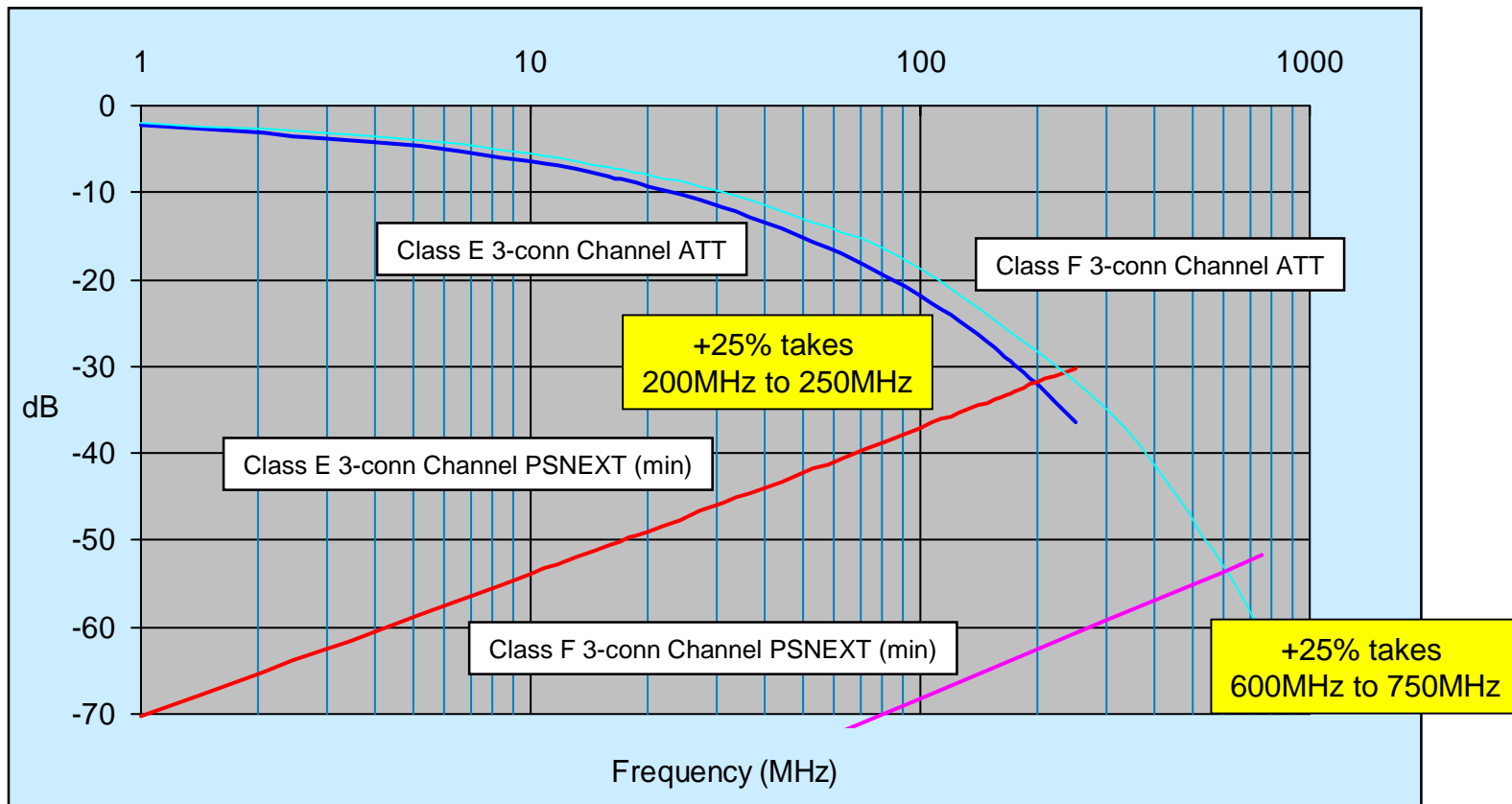
Outstanding Issues, Cat. 7





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Frequency Specification





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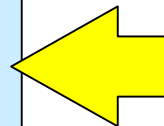
Cabling performance

Application support

Application development and
equipment choices

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Can we buy them?
When can we buy them?
What are the risks?
Where we will they be used?
Why would they be used?

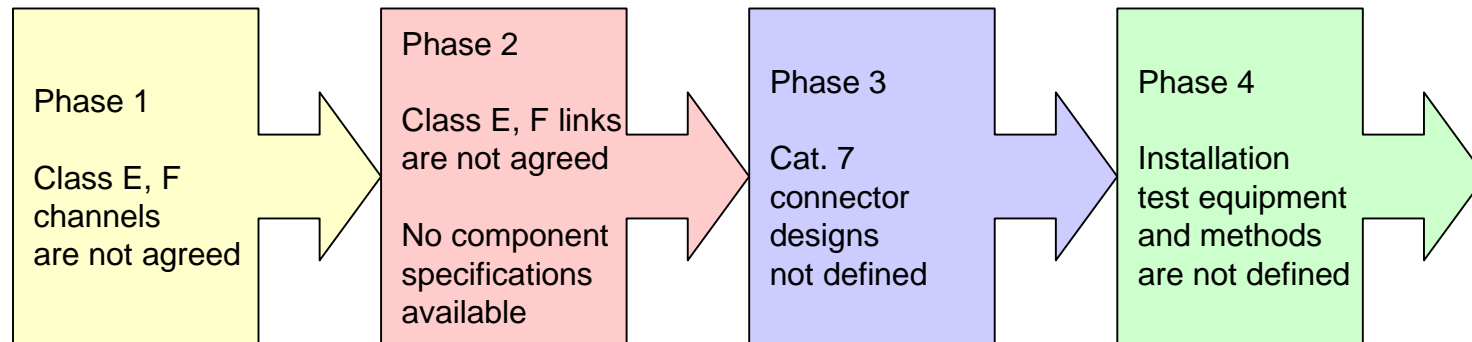




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Can we buy them?

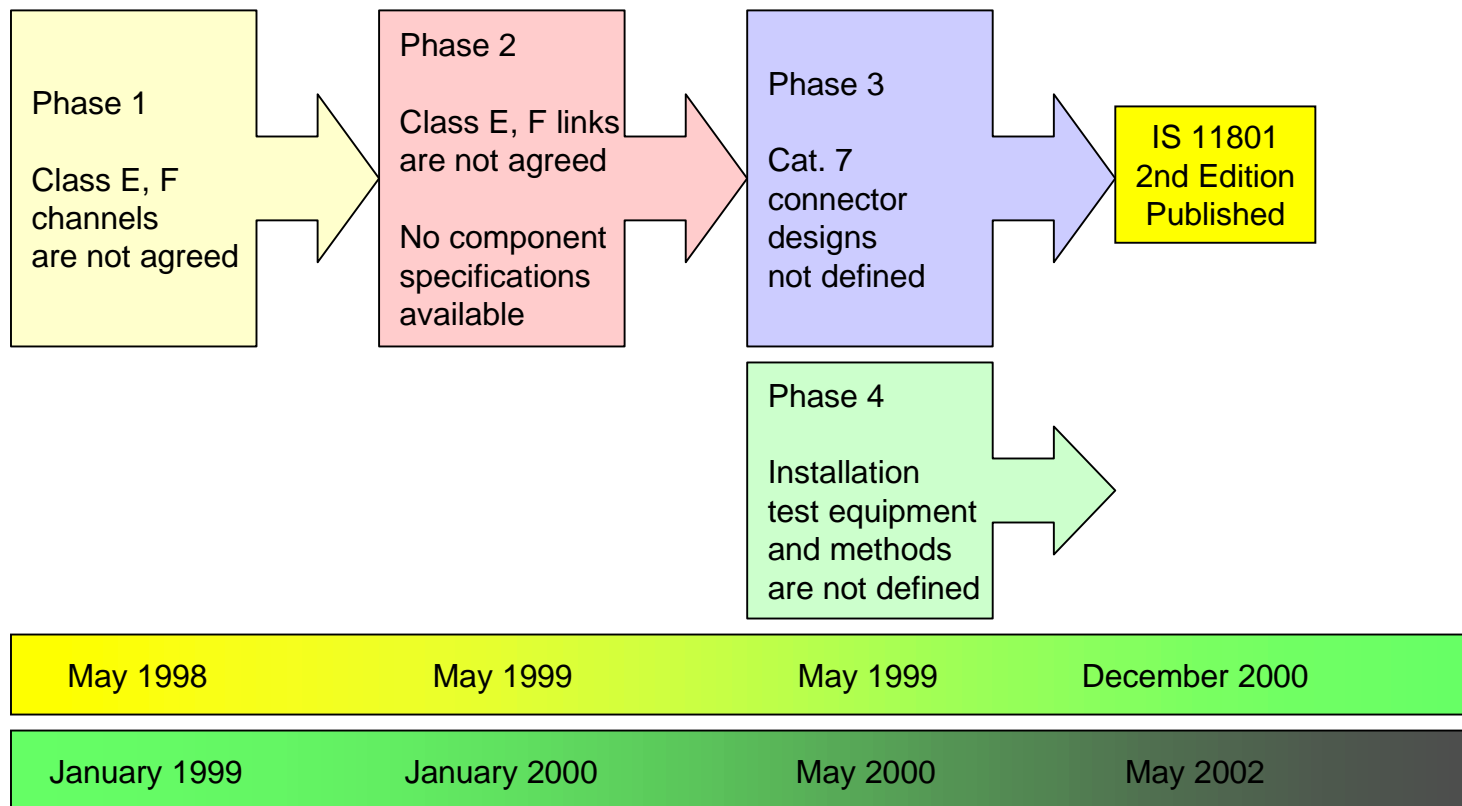
NO





DATA CABLING - BACK IN THE MELTING POT?

When can we buy them?





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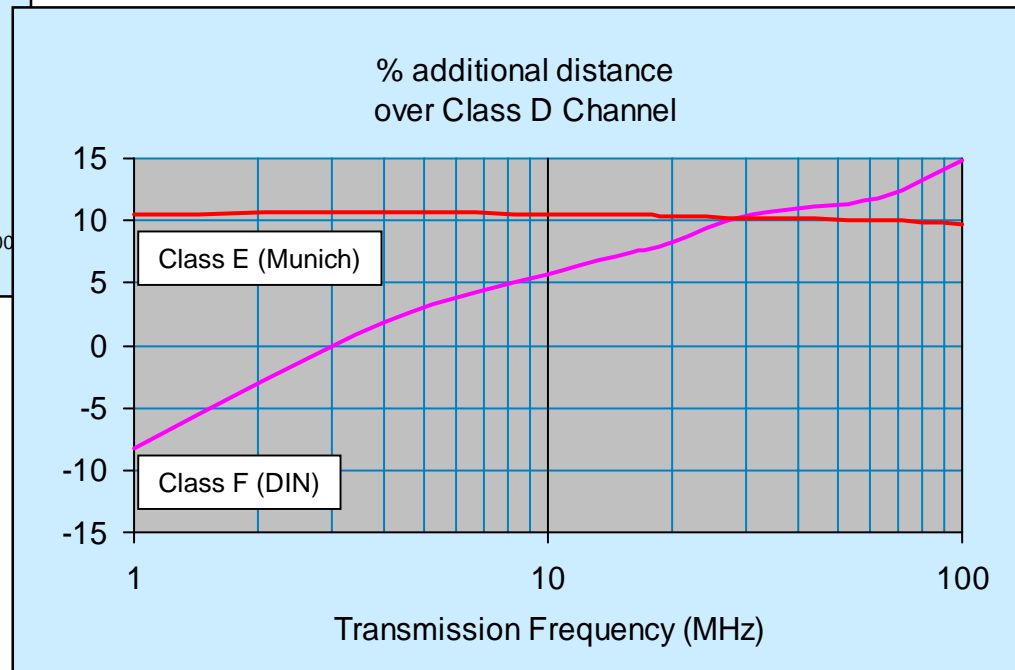
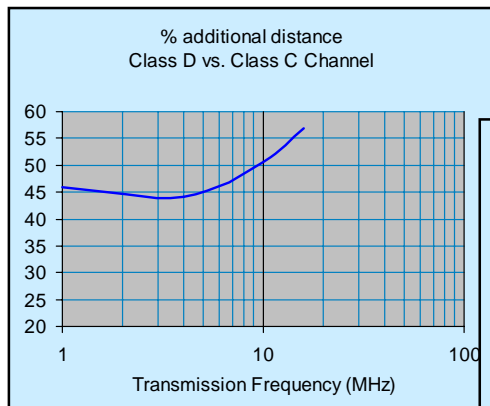
What are the risks?

- 1st Prize
 - best view
 - products purchased in advance of the standard may not be Cat. 6 or Cat. 7
- BIG DEAL
 - so why buy them at all?
- 2nd Prize
 - worst view
 - products purchased in advance of the standard may be wholly proprietary
 - backwards compatibility is a major issue
 - major potential cost of network support



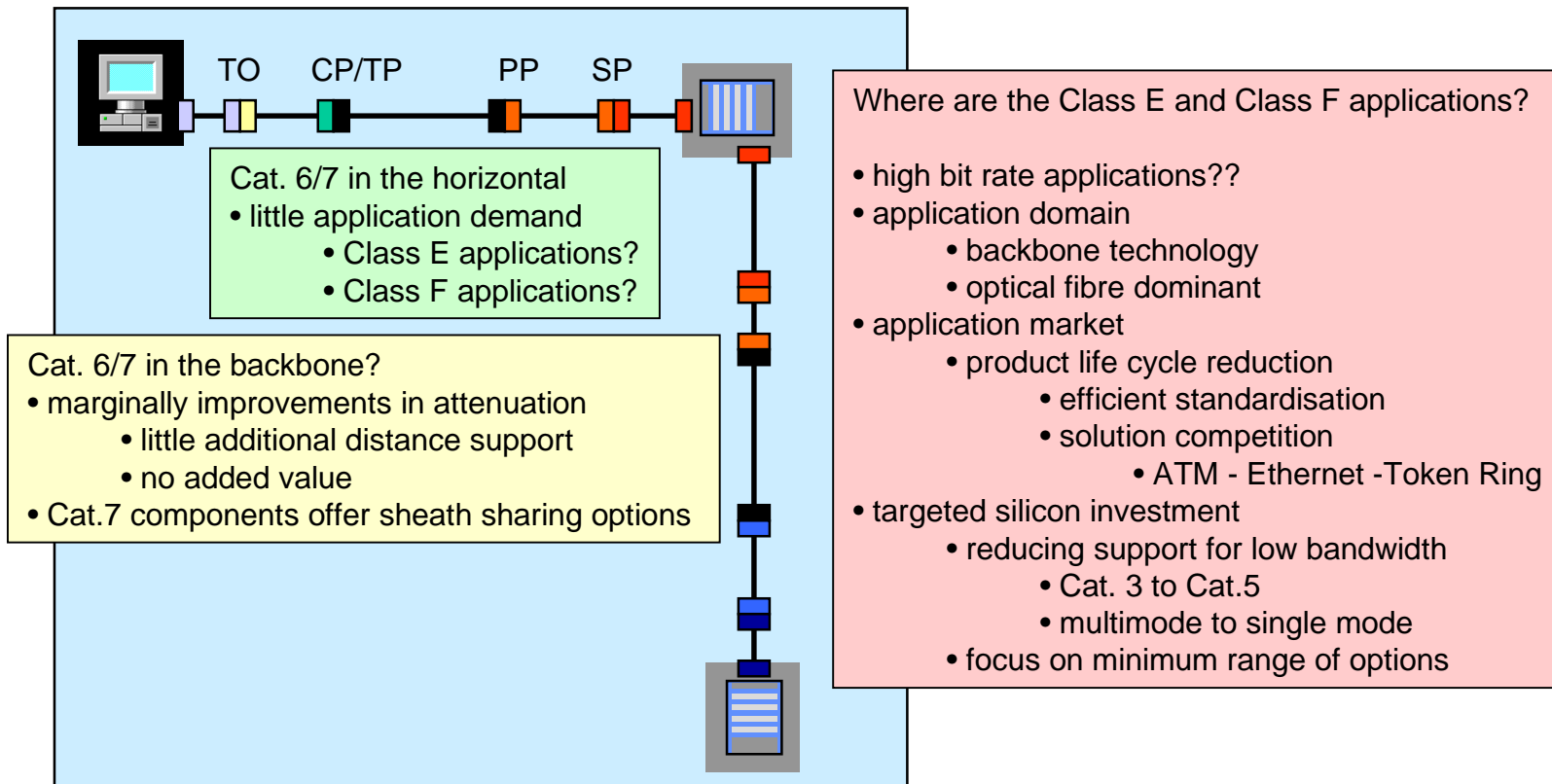
DATA CABLING - BACK IN THE MELTING POT?

Where would they be used?





Why would they be used?





DATA CABLING - BACK IN THE MELTING POT?

Backwards Compatibility

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.“

Until significant standardisation work is undertaken it would be foolhardy to assume that any components offered as “Category 6/7” or meeting the draft versions of such specifications will meet either of these objectives



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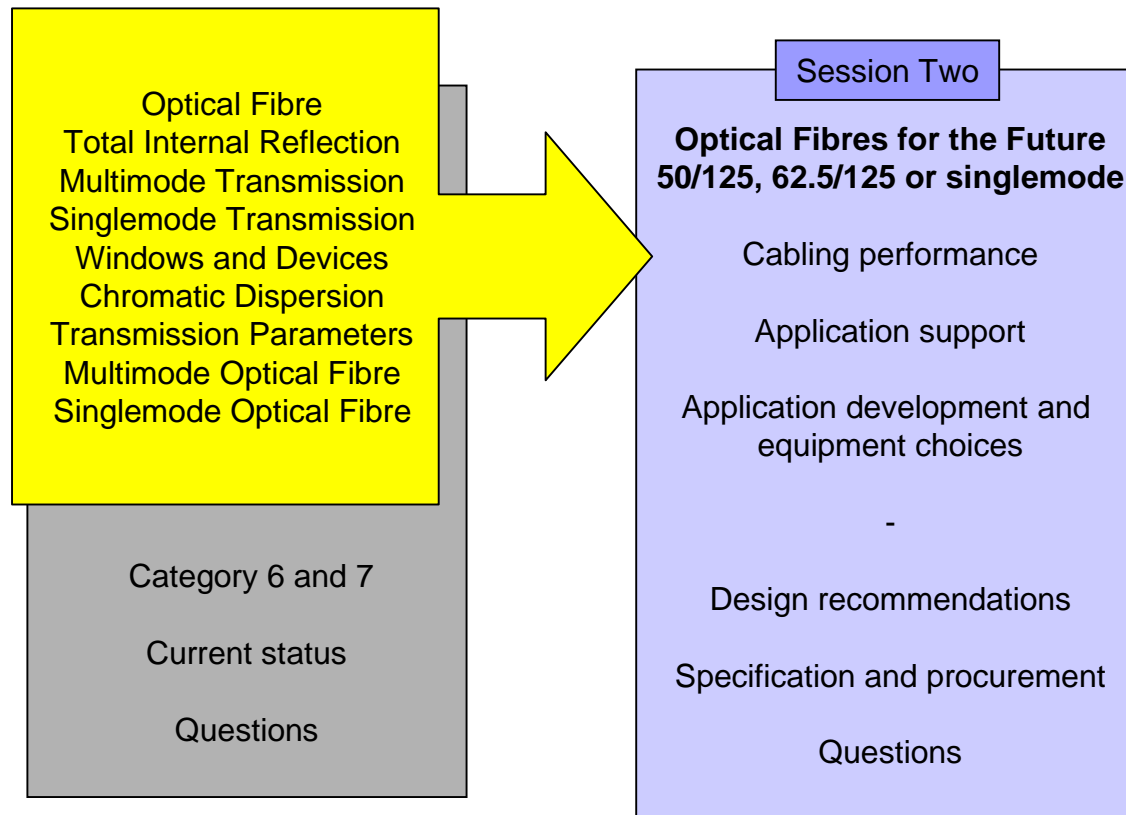
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DATA CABLING - BACK IN THE MELTING POT?

Optical Fibre



The concept

Core and cladding have different optical properties

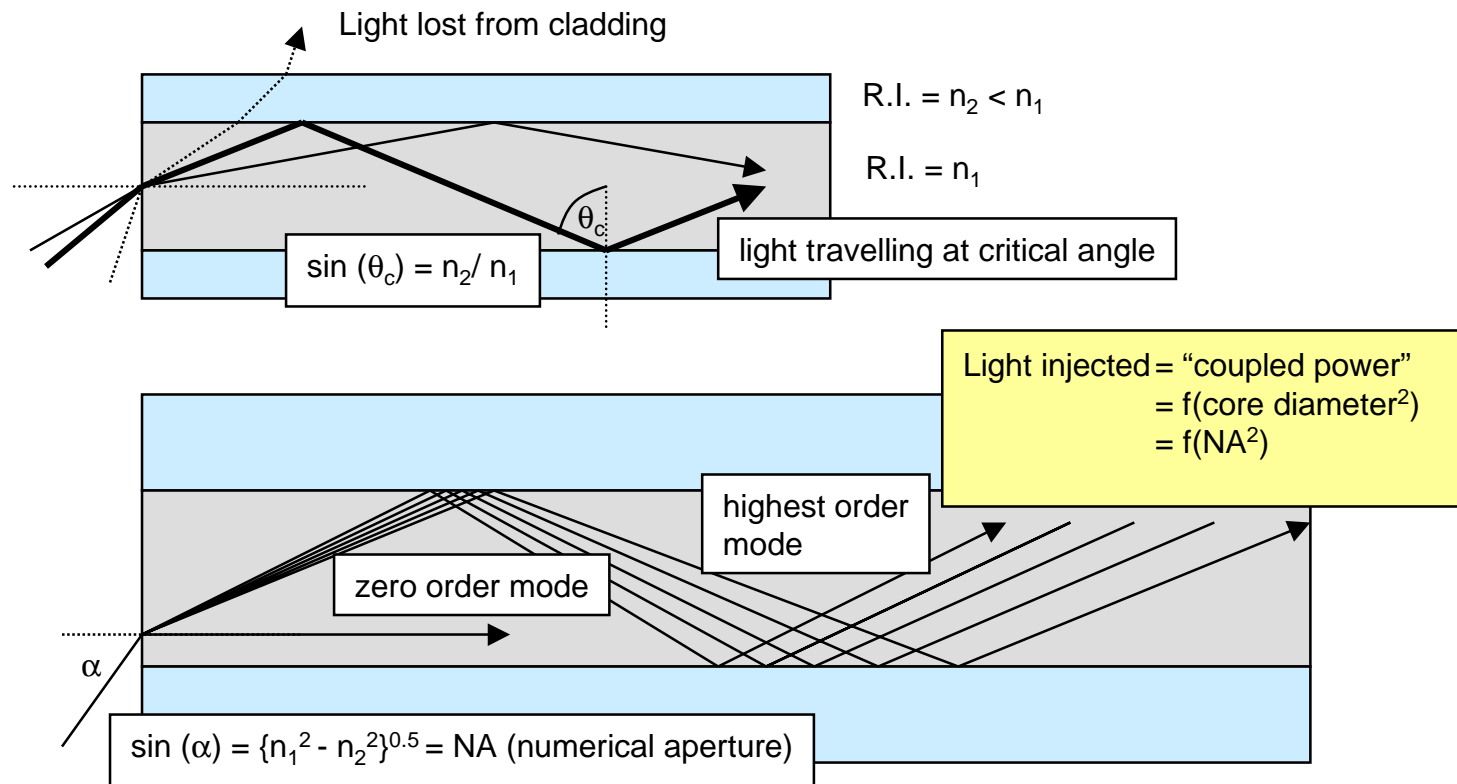
Refractive index (R.I.) $n_x = c/v_x$
 c = speed of light in a vacuum
 v_x = speed of light in material x

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



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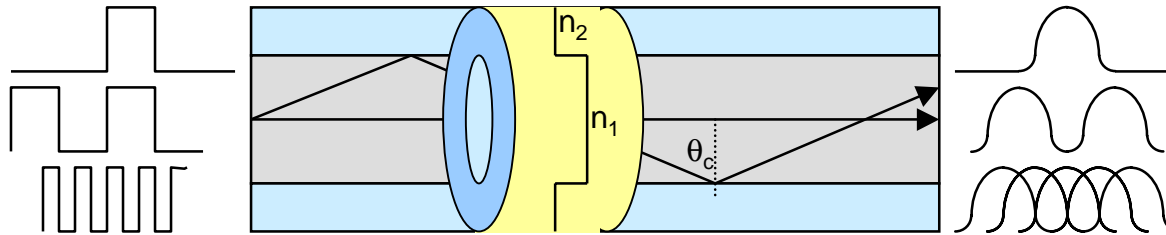
Total Internal Reflection



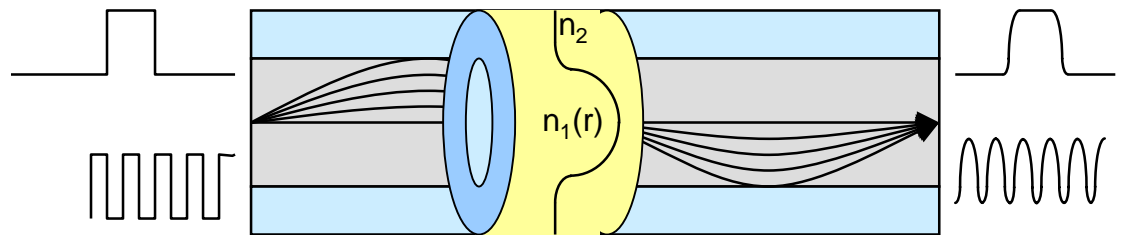


DATA CABLING - BACK IN THE MELTING POT?

Multimode Transmission



STEP (PED) INDEX (S.I.) MULTIMODE OPTICAL FIBRE
 Path lengths: maximum variation Bandwidth: modal dispersion limited
 Path times: maximum variation



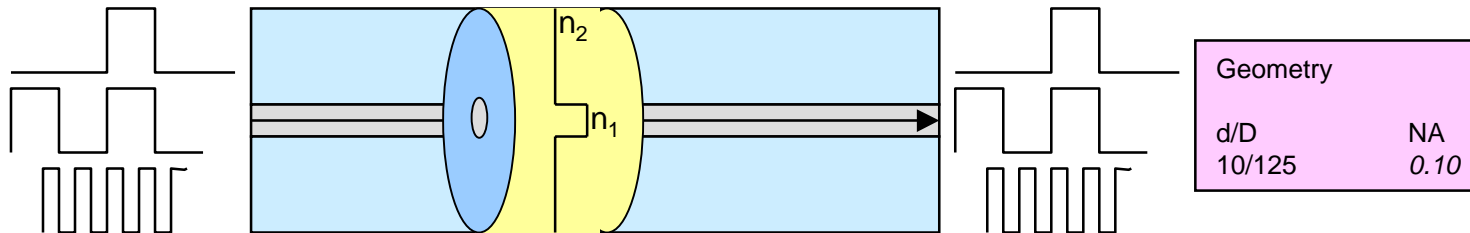
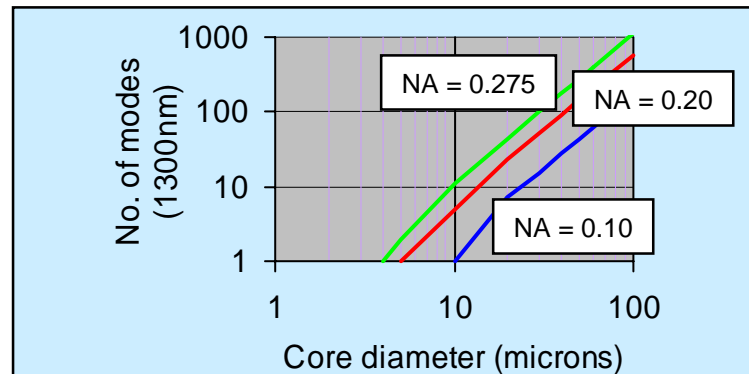
| Geometry options | |
|------------------|-------|
| d/D | NA |
| 50/125 | 0.20 |
| 62.5/125 | 0.275 |

GRADED INDEX (G.I.) MULTIMODE OPTICAL FIBRE
 Path lengths: significant variation Bandwidth: 1st order: modal dispersion
 Path times: limited variation 2nd order: chromatic dispersion



DATA CABLING - BACK IN THE MELTING POT?

Singlemode Transmission

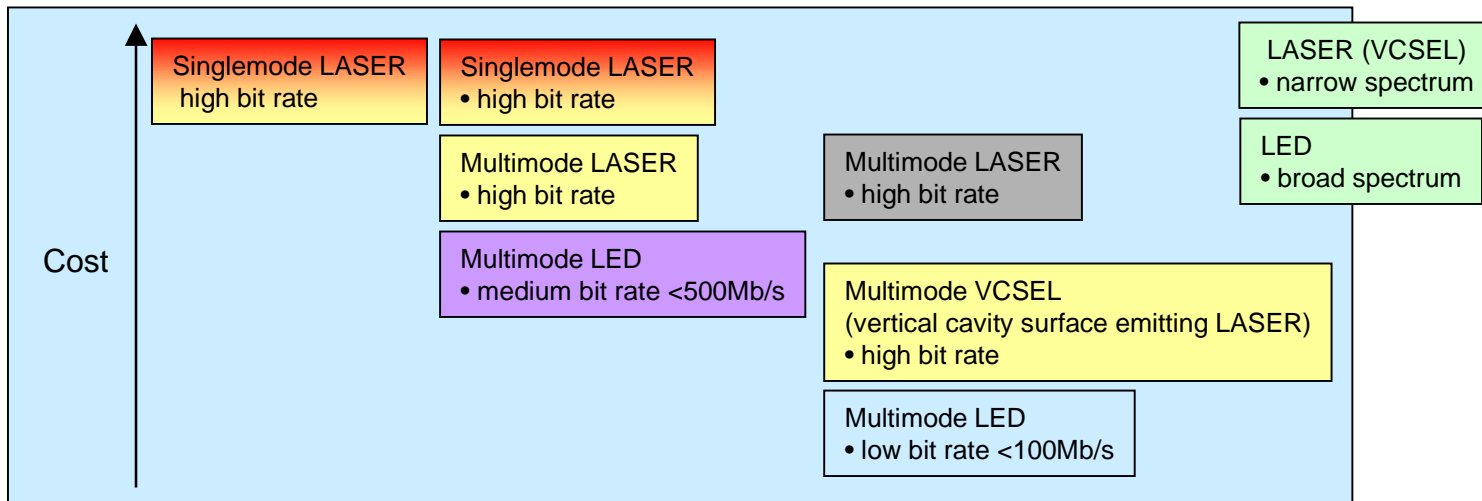
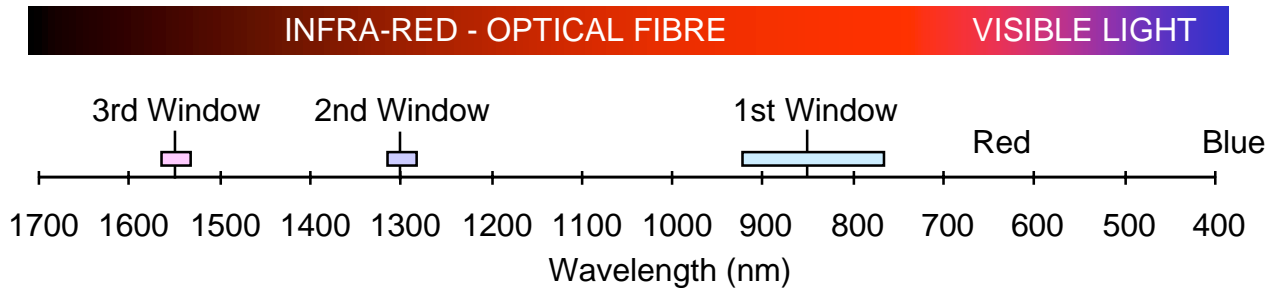


STEP(PED) INDEX (S.I.) SINGLE MODE (*monomode*) OPTICAL FIBRE
 Path lengths: no variation Bandwidth: 1st order: chromatic dispersion
 Path times: no variation 2nd order: pulse shape dispersion



DATA CABLING - BACK IN THE MELTING POT?

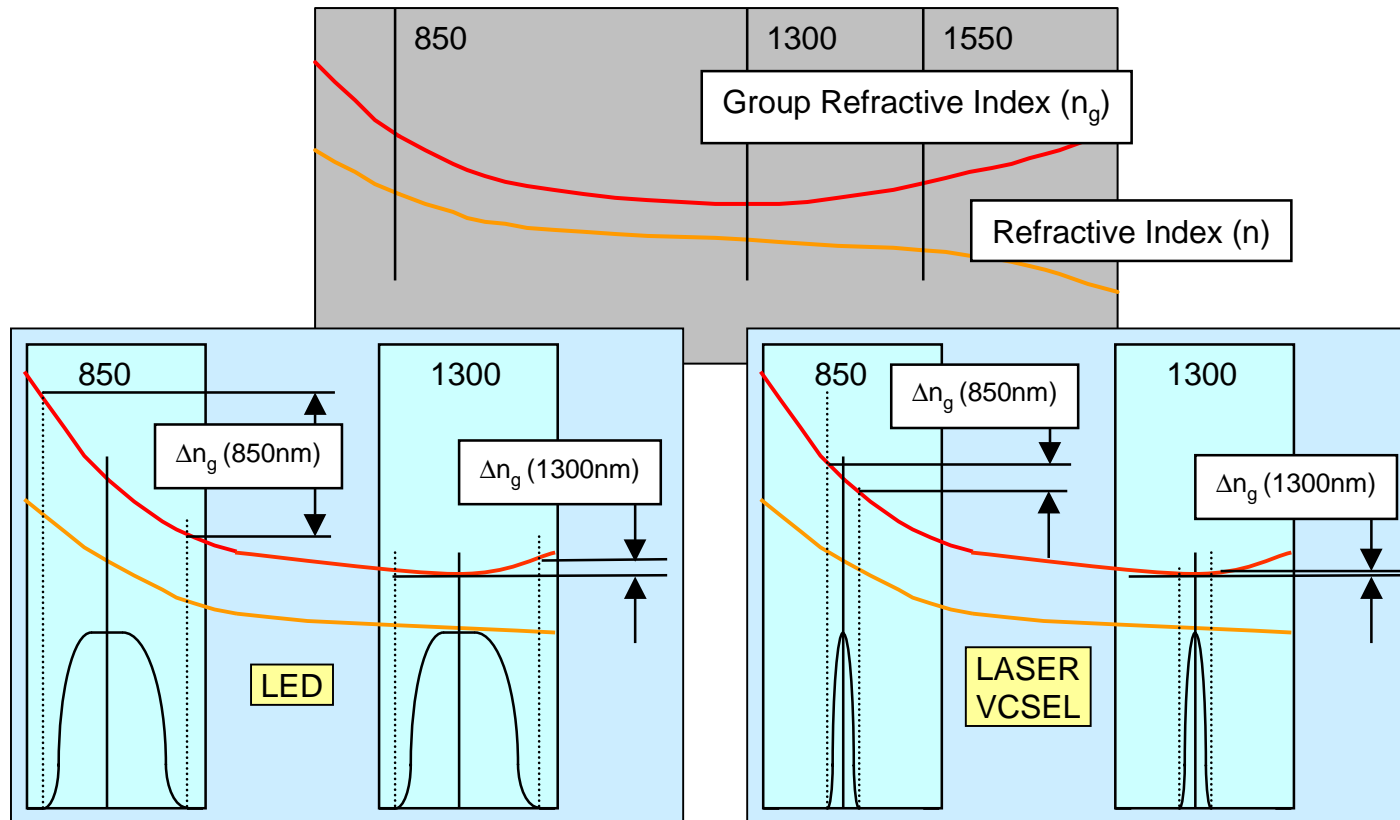
Windows and Devices





DATA CABLING - BACK IN THE MELTING POT?

Chromatic Dispersion



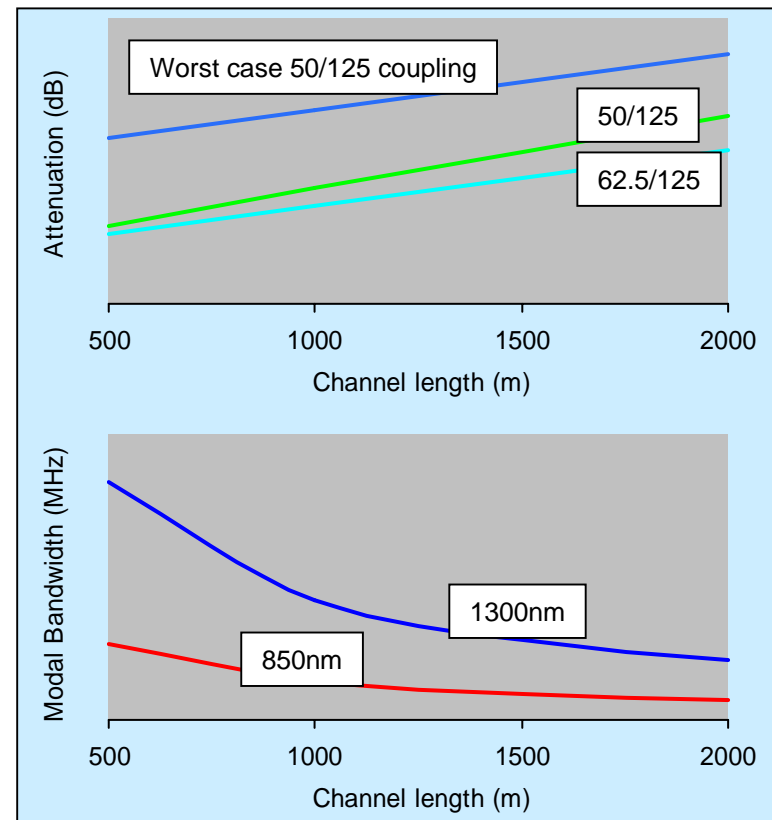


DATA CABLING - BACK IN THE MELTING POT?

Transmission Parameters

| Optical fibre parameters | | | |
|--------------------------|------------|-------|--------|
| Wavelength | | 850nm | 1300nm |
| Attenuation coefficient | | | |
| | dB/km max. | ? | ? |
| Modal Bandwidth | | | |
| | MHzkm min. | ? | ? |

| Coupling | | |
|----------|---------|-------------------------------------|
| Launch | Receive | Loss |
| 62.5µm | 50µm | 4.7dB worst case 1-2dB typically |





DATA CABLING - BACK IN THE MELTING POT?

Multimode Optical Fibre

| Defined dual window attenuation options | | |
|---|---------------------------|----------------------------|
| Geometry (µm) | Attenuation 850nm (dB/km) | Attenuation 1300nm (dB/km) |
| 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 |
| IS 11801/ EN 50173 | 3.5 | 1.0 |
| ANSI/TIA/EIA568A | 3.75 | 1.5 |

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

| Defined dual window bandwidth options | | |
|---------------------------------------|-------------------------|--------------------------|
| Geometry (µm) | Bandwidth 850nm (MHzkm) | Bandwidth 1300nm (MHzkm) |
| 62.5/125 | 160 | 200 |
| 62.5/125 | 160 | 500 |
| 62.5/125 | 200 | 200 |
| 50/125 and 62.5/125 | 200 | 400 |
| IS 11801/EN 50173 | 200 | 500 |
| 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 |
| 50/125 | 500 | 500 |
| 50/125 | 600 | 1000 |



DATA CABLING - BACK IN THE MELTING POT?

Singlemode Optical Fibre

THE BENEFITS OF SINGLEMODE TECHNOLOGY

- highest possible bandwidth
 - limited by device spectral width
- easiest to
 - manufacture
 - predict
 - test
- lowest
 - attenuation
 - cost

Current singlemode specification

Parameter

| | |
|----------------------------|----------------------------|
| Attenuation coefficient | |
| @ 1310nm | 1.0 dB/km max. |
| @ 1550nm | 1.0 dB/km max. |
| Zero dispersion wavelength | 1300-1324 nm |
| Dispersion slope | 0.093ps/km.nm ² |
| Cut-off wavelength | 1280 max. |

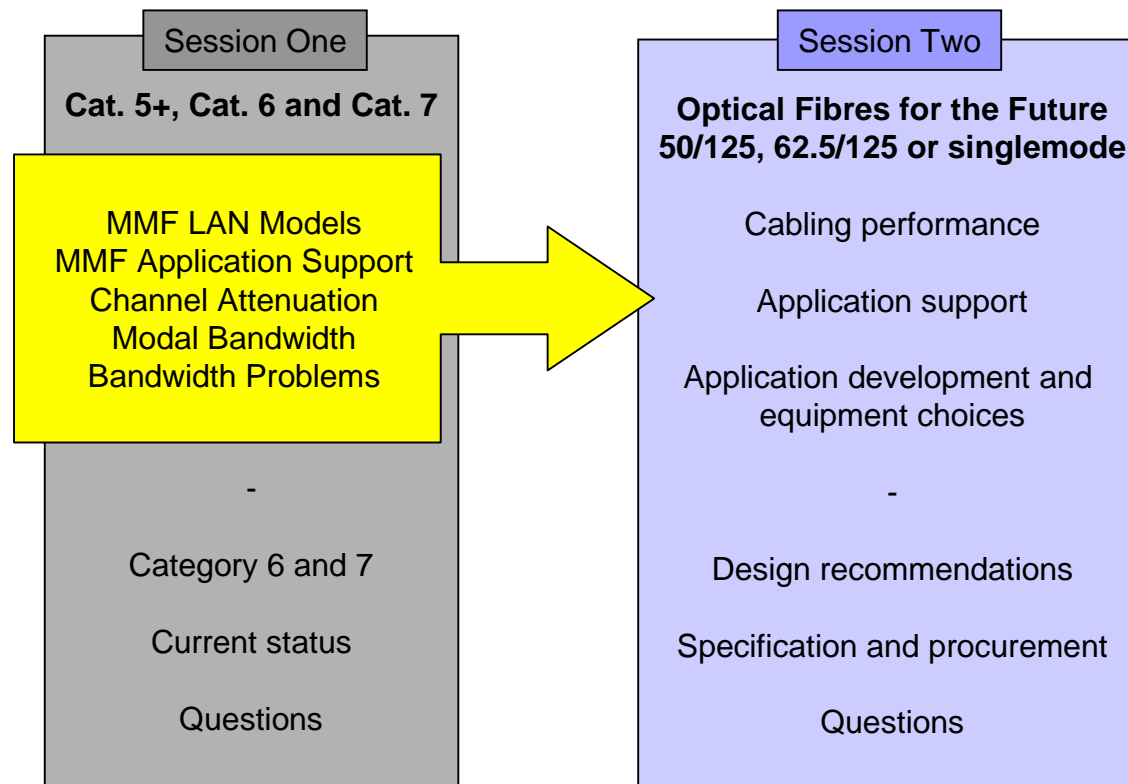
Proposed change to singlemode specification

| | |
|-------------------------|----------------|
| Attenuation coefficient | |
| @ 1310nm | 0.5 dB/km max. |
| @ 1550nm | 1.0 dB/km max. |



DATA CABLING - BACK IN THE MELTING POT?

Agenda





DATA CABLING - BACK IN THE MELTING POT?

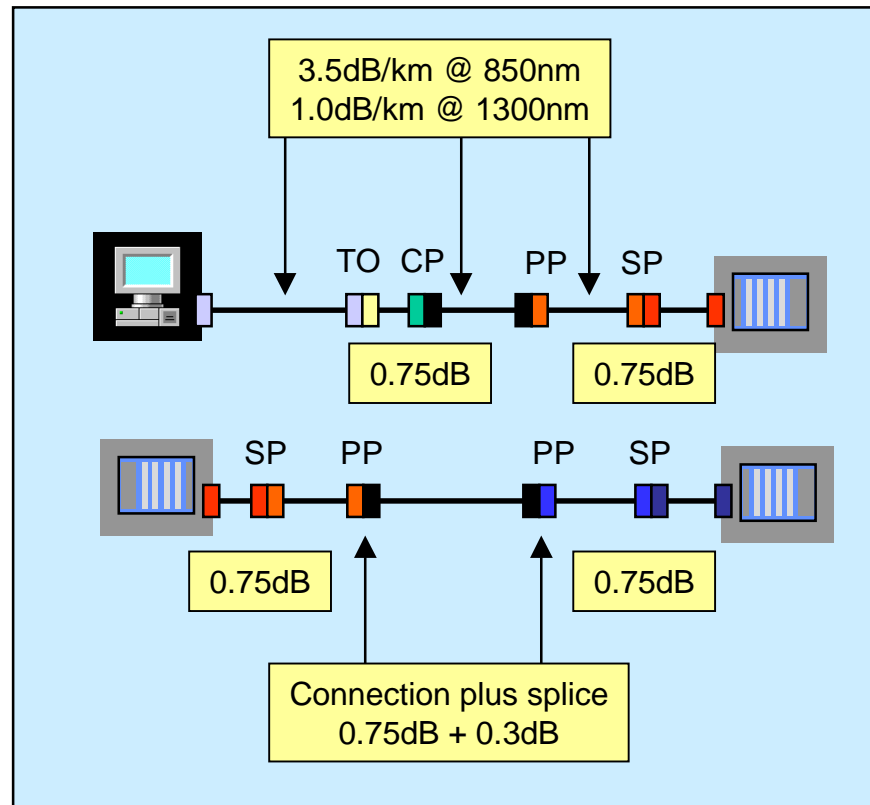
MMF LAN Models

First Window
(850nm)

FOIRL
10base-FL/FB
Token Ring 4/16
802.12 Demand Priority
ATM 52
ATM 155
ATM 622
FiberChannel - 133/266
FiberChannel - 531
FiberChannel - 1062
1000BASE-SX

Second Window
(1300nm)

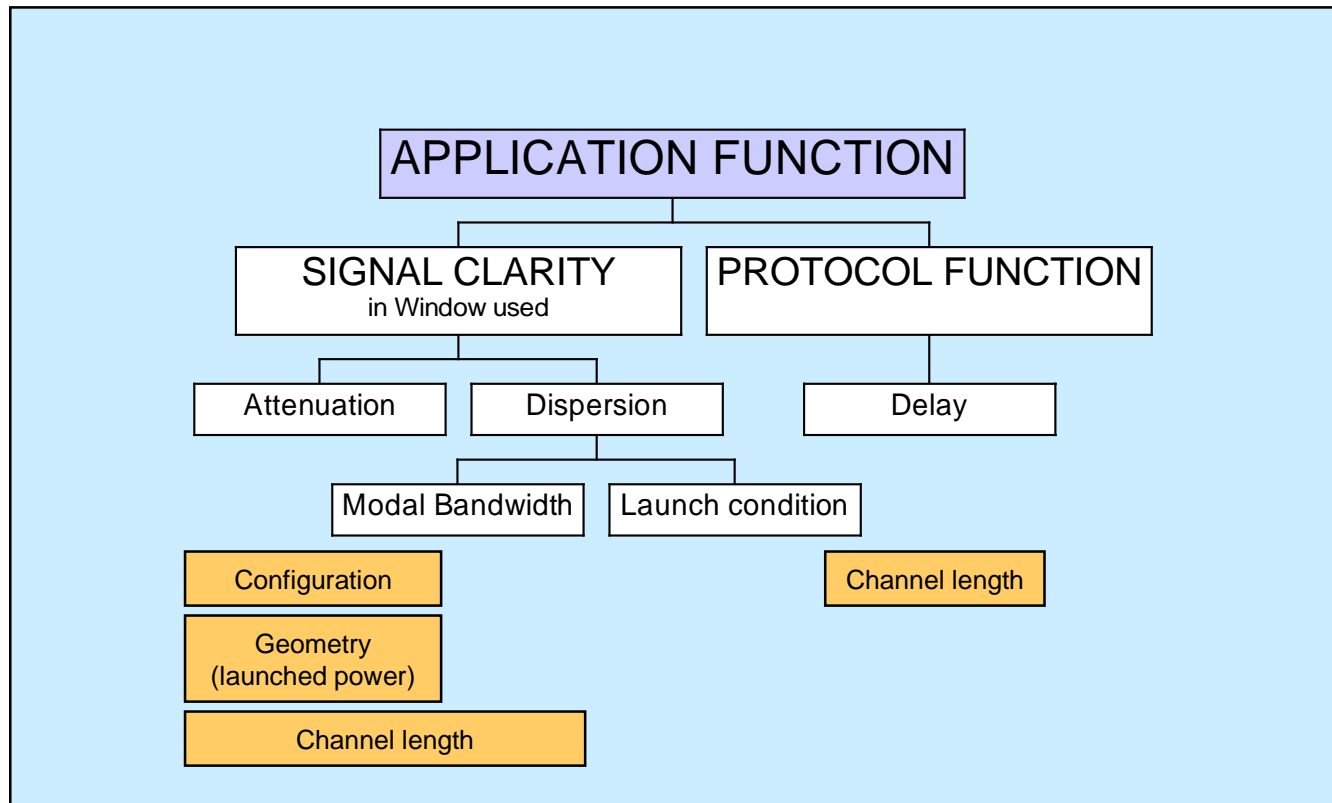
FDDI - PMD
100Base-FX
802.12 Demand Priority
ATM 155
ATM 622
FiberChannel - 133/266
1000BASE-LX





DATA CABLING - BACK IN THE MELTING POT?

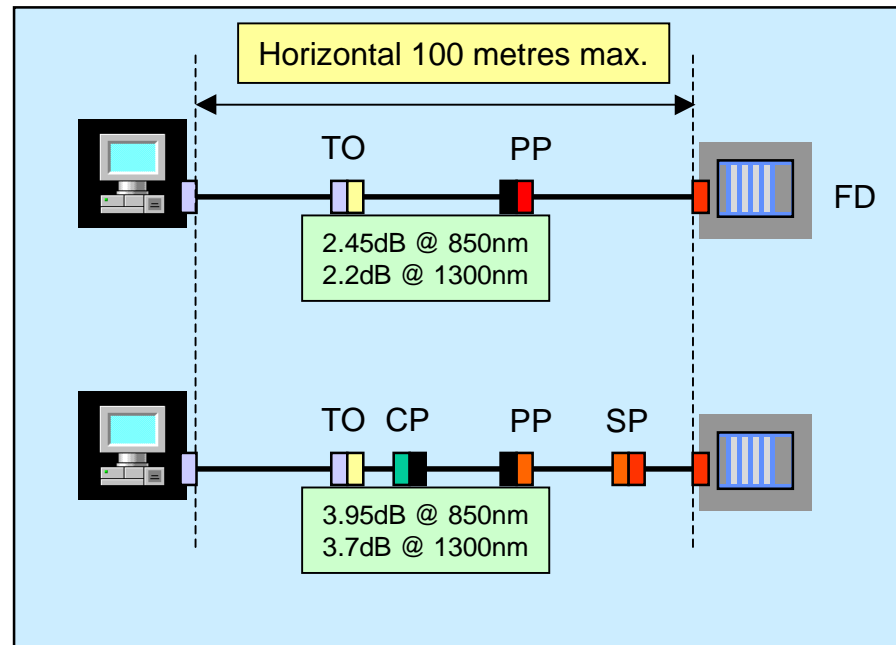
MMF Application Support





DATA CABLING - BACK IN THE MELTING POT?

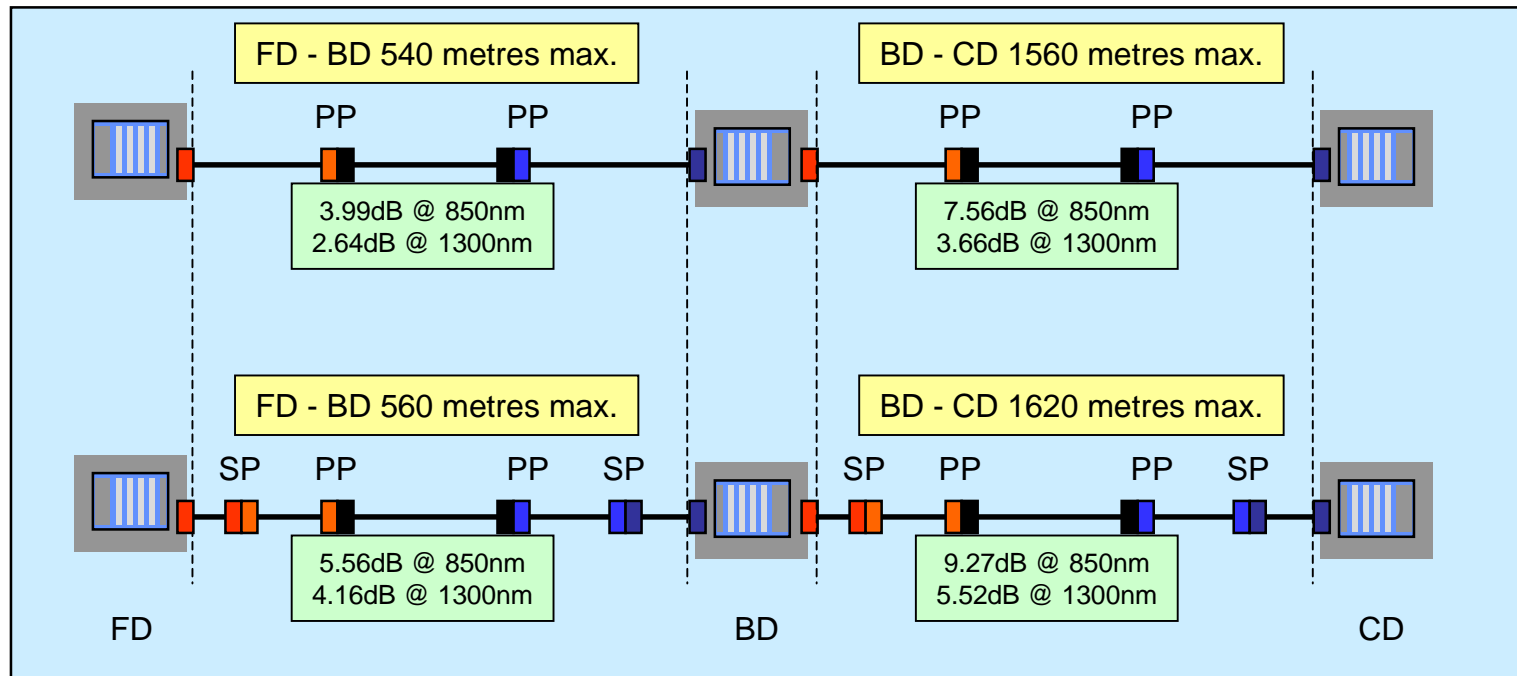
Channel Attenuation - I





DATA CABLING - BACK IN THE MELTING POT?

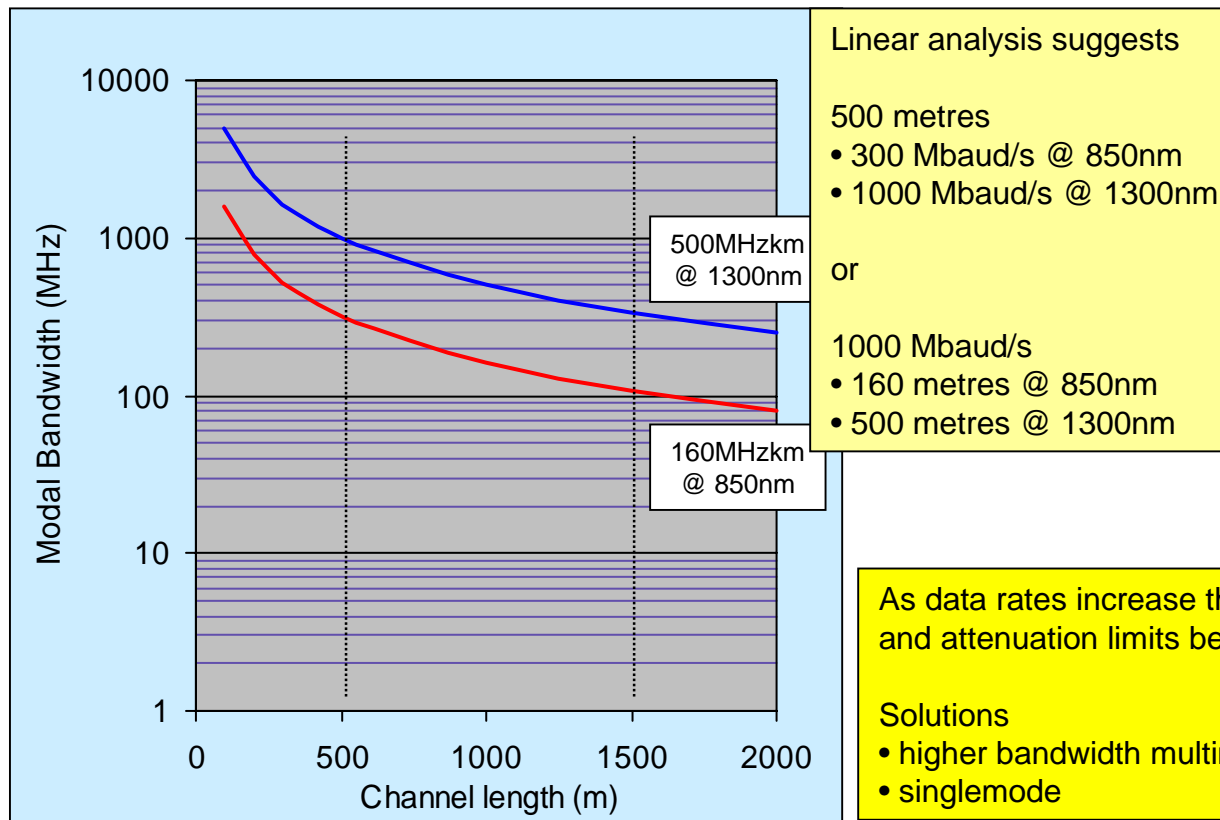
Channel Attenuation - II





DATA CABLING - BACK IN THE MELTING POT?

Modal Bandwidth



Linear analysis suggests

500 metres

- 300 Mbaud/s @ 850nm
- 1000 Mbaud/s @ 1300nm

or

1000 Mbaud/s

- 160 metres @ 850nm
- 500 metres @ 1300nm

As data rates increase the conventional distances and attenuation limits become irrelevant

Solutions

- higher bandwidth multimode
- singlemode



DATA CABLING - BACK IN THE MELTING POT?

Bandwidth Problems

LAUNCH CONDITIONS

- modal bandwidth
 - factory measurement
 - over-filled launch condition
 - defined spectral width
- to deliver high bit rates
 - LASERs/VCSELs used
 - coherent light
 - collimated beam

LASER/VCSEL bandwidth problems identified

- preform-manufacture dependent

Immediate solution

- modify equipment launch condition
- done for MMF 1000baseF (SX and LX)

Long term solution

- modify tests at factory to reflect LASER launch

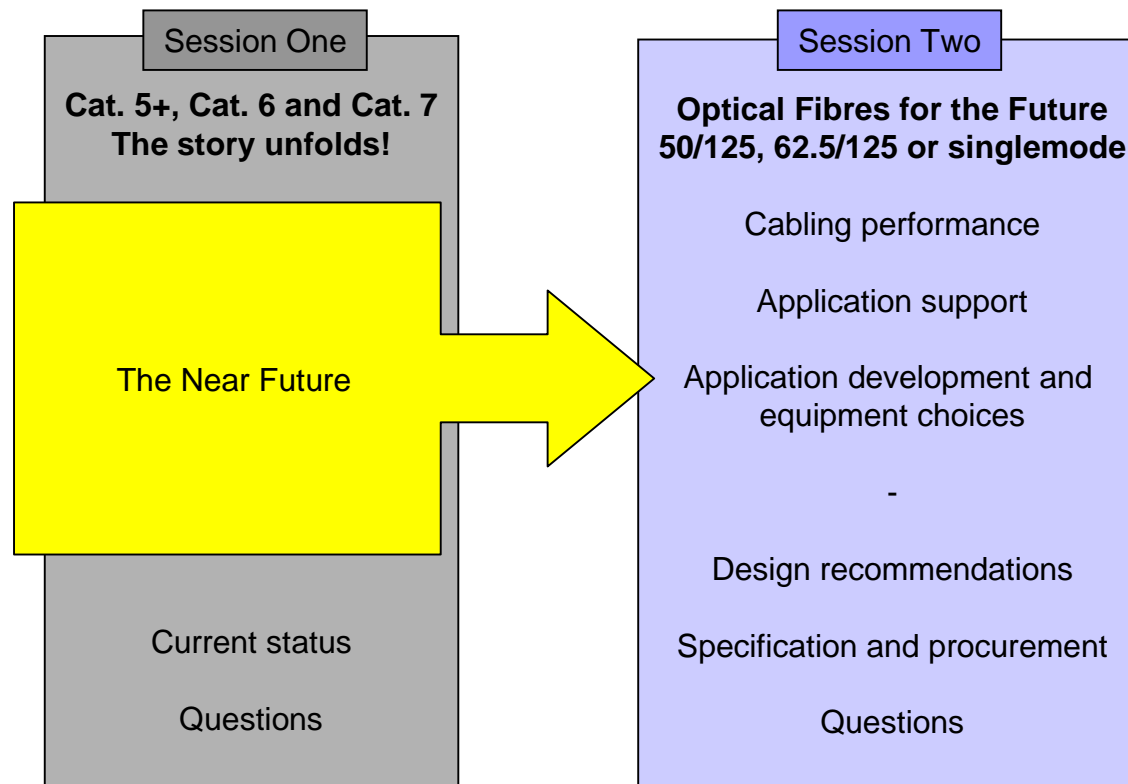
MAIN PROBLEM

Few installers/users have knowledge of installed base



DATA CABLING - BACK IN THE MELTING POT?

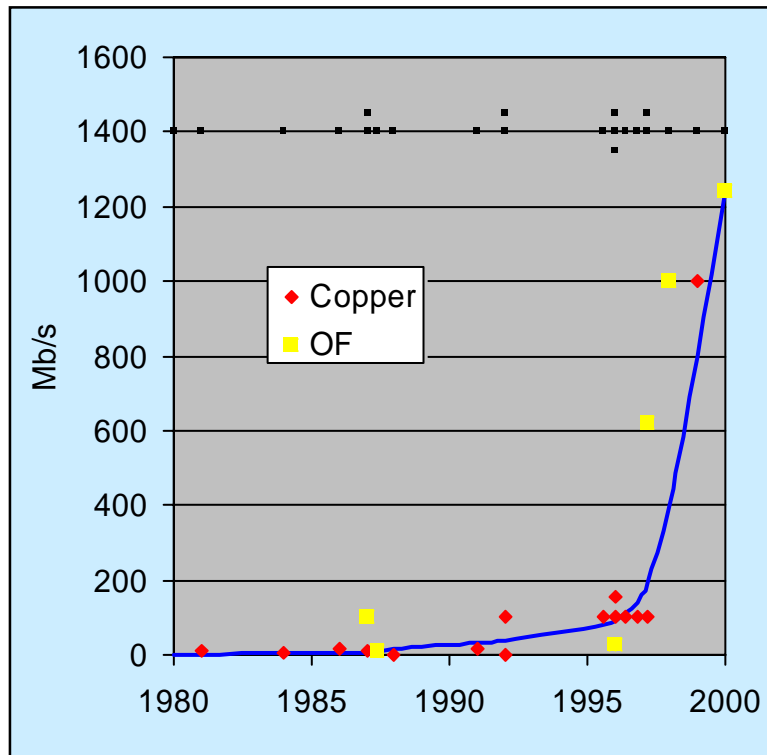
Agenda





DATA CABLING - BACK IN THE MELTING POT?

The Near Future



Multimode optical fibre

Support in 1st Window

- distances will diminish
 - using LASERs/VCSELs
 - too short for realistic backbone support
- solutions
 - use higher bandwidth product
 - 50/125?
 - develop coding technologies similar to copper

Support in 2nd Window

- expensive devices
- solution
 - develop 2nd Window VCSEL technology
 - realistic limit 4Gb/s
 - develop coding technologies similar to copper

LIMITS ARE JUST AROUND THE NEXT BEND!!!



DATA CABLING - BACK IN THE MELTING POT?

Agenda

Session One

Cat. 5+, Cat. 6 and Cat. 7
The story unfolds!

Category 5 (1995)

Complex application support

Category 5 (1998)

-

Category 6 and 7

Current status

Questions

Session Two

Optical Fibres for the Future
50/125, 62.5/125 or singlemode

Cabling performance

Application support

Application development and
equipment choices

Break

Design recommendations

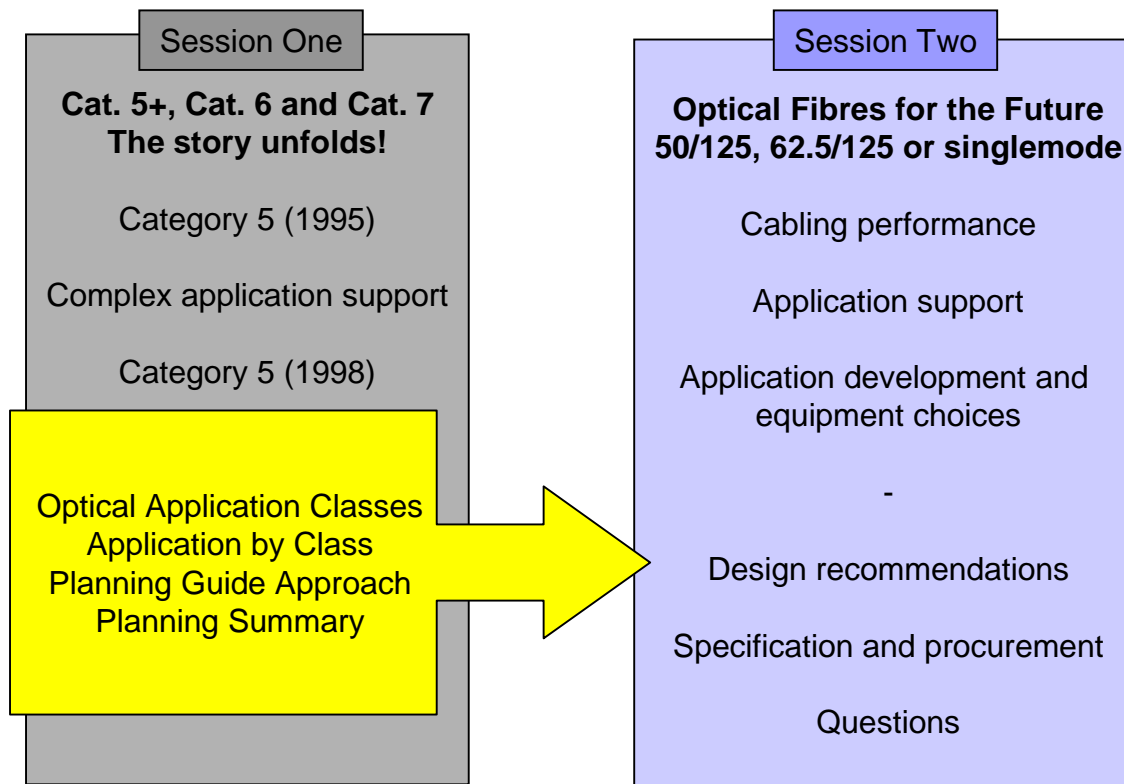
Specification and procurement

Questions



DATA CABLING - BACK IN THE MELTING POT?

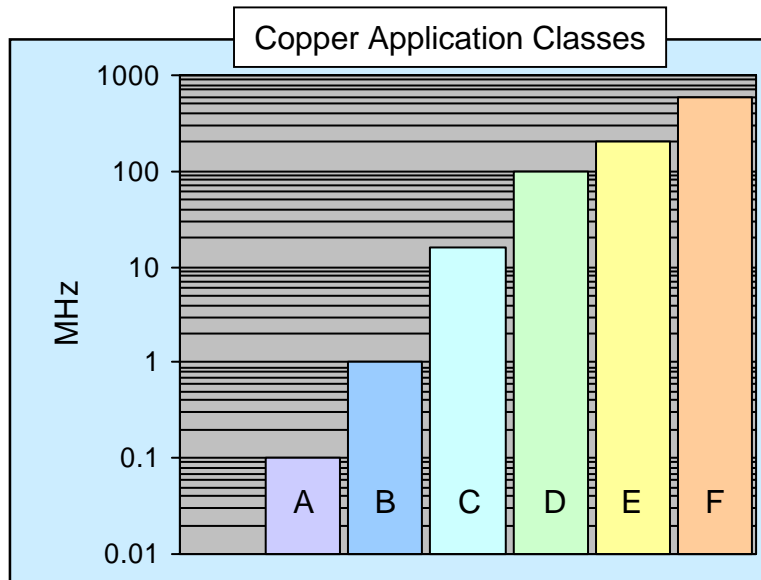
Agenda





DATA CABLING - BACK IN THE MELTING POT?

Optical Application Classes



PROPOSALS FOR OPTICAL APPLICATION CLASSES

Complex discussions underway
One option has been discussed but is not fully developed

Alternatives include a "Planning Guide Approach"

PLANNING GUIDE APPROACH

| Class | Window | Definition (based on bandwidth) |
|-------|-------------|--|
| OA-1 | 1st MMF | > 2000m on 160MHzkm |
| OA-2 | 2nd MMF | > 2000m on 500MHzkm |
| OB-1 | 1st MMF | > 500m on 160MHzkm |
| OB-2 | 2nd MMF | > 500m on 500MHzkm |
| OC-1 | 1st MMF | > 160m on 160MHzkm and > 500m on 500MHzkm |
| OC-12 | 1st/2nd MMF | < 500m on 500MHzkm |
| OS | 2nd/3rd SMF | Supported over 2000m |



DATA CABLING - BACK IN THE MELTING POT?

Application by Class

Class OA-1

ISO/IEC 8802-3 10Base-FL
ISO/IEC 8802-3 10Base-FB
ISO/IEC 8802-3 FOIRL
ISO/IEC 11802-4 Token Ring 4/16
IEEE 802-12 Demand Priority
ATM-52

Class OB-1

ATM-155
FiberChannel 133
FiberChannel 266

Class OC-1

IEEE 802-3 1000Base-SX
ATM-622
FiberChannel 531
FiberChannel 1062

Class OS

ISO/IEC 9314-3 FDDI-PMD
IEEE 802-3 1000Base-SMF

Class OA-2

ISO/IEC 9314-3 FDDI
ISO/IEC 8802-3 100Base-FX
IEEE 802-12 Demand Priority
ATM-52
ATM-155
FiberChannel 133
FiberChannel 266

Class OB-2

IEEE 802-3 1000Base-LX

Class OC-12

???????



DATA CABLING - BACK IN THE MELTING POT?

Planning Guide Approach

Basic specification for optical fibres used

- 62.5/125, 160/500MHzkm
- 50/125, 500/500MHzkm

Campus Backbone Planning

0 - 160 metres

- Class OA, Class OB and OC
 - 62.5/125 μ m
 - 50/125 μ m (provided coupling losses acceptable)

160 - 500 metres

- Class OA and Class OB
 - 62.5/125 μ m
 - 50/125 μ m (provided coupling losses acceptable)
- Class OC-1
 - 50/125 μ m (provided coupling losses acceptable)
- Class OC-12
 - higher bandwidth multimode (>500/500) required

500 - 2000 metres

- Class OA
 - 62.5/125 μ m
 - 50/125 μ m (provided coupling losses acceptable)
- Class OB and OC
 - higher bandwidth multimode (>500/500) required

Single mode installed to support Class OS

Building Backbone Planning

0 - 160 metres

- Class OA, Class OB and OC
 - 62.5/125 μ m
 - 50/125 μ m (provided coupling losses acceptable)
- Single mode installed only as Class OS are implemented

160 - 500 metres

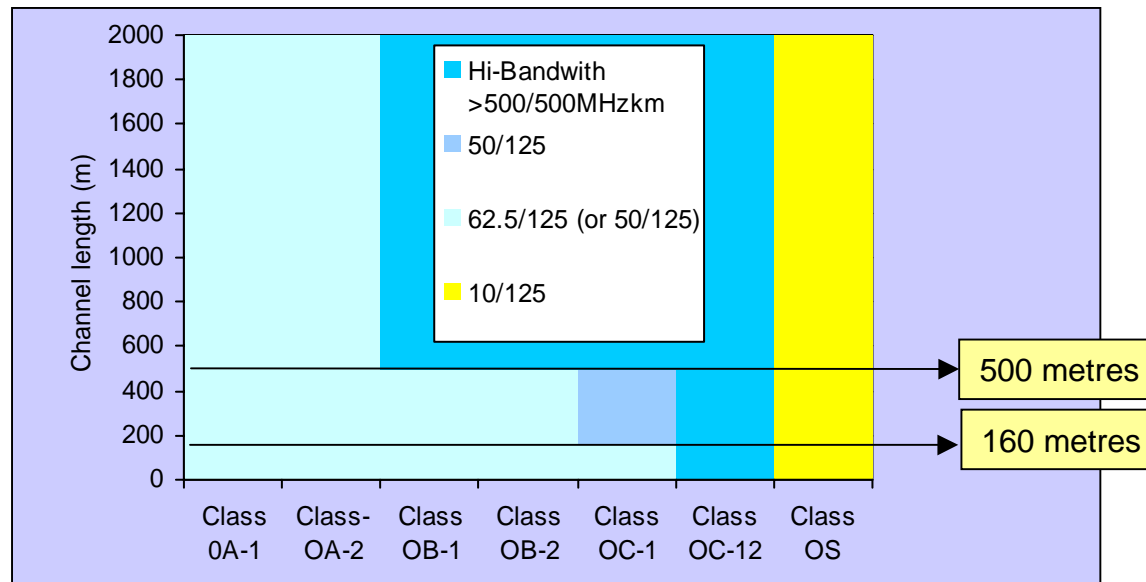
- Class OA and Class OB
 - 62.5/125 μ m
 - 50/125 μ m (provided coupling losses acceptable)
- Class OC-1
 - 50/125 μ m (provided coupling losses acceptable)
- Class OC-12
 - higher bandwidth multimode (>500/500) required

Single mode installed only as Class OS are implemented



DATA CABLING - BACK IN THE MELTING POT?

Planning Summary

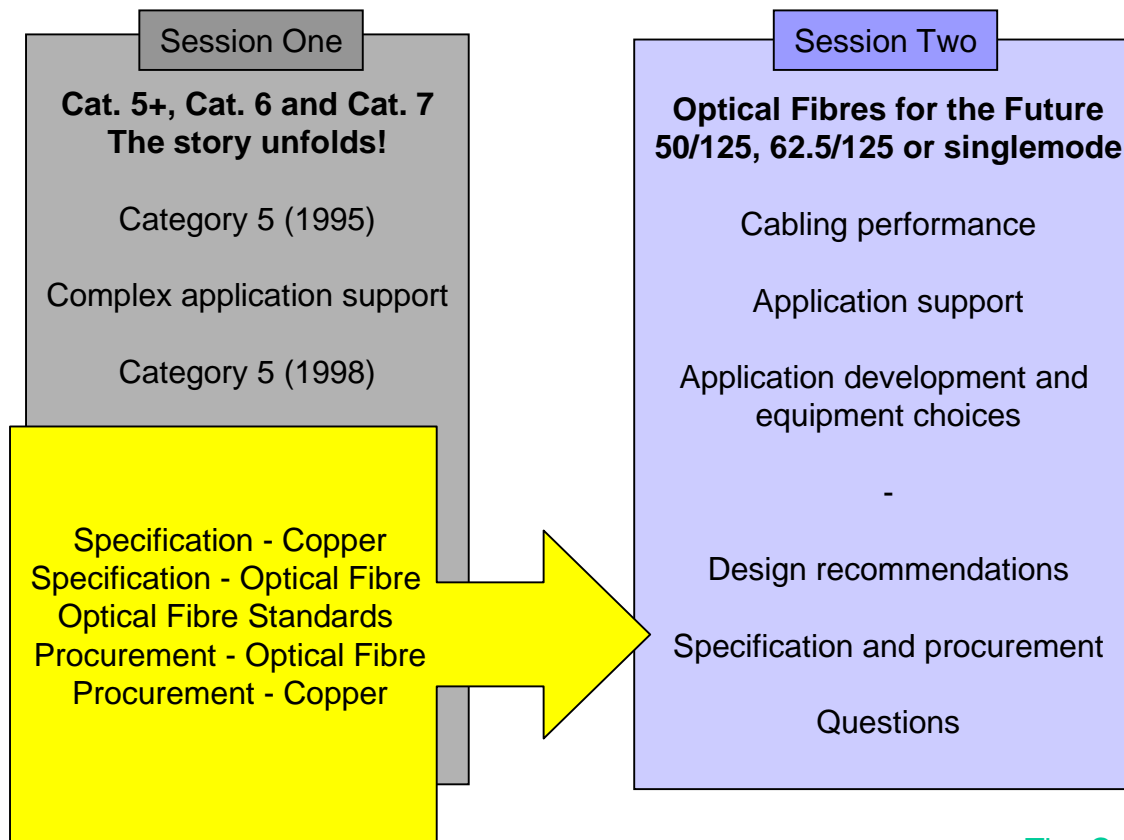


Actual support over a particular length and configuration depends upon application/product specification



DATA CABLING - BACK IN THE MELTING POT?

Agenda





Specification - Copper

Balanced pair copper

- Category 5 (1998)
 - continues to dominate in horizontal
 - Gigabit technologies support design limit
 - without consolidation points/crossconnects
 - Category 6 offers
 - enhanced noise performance and higher frequencies
 - IEEE prefer lower attenuation for DSP
 - possible conflict with EMC at higher frequencies
 - major concerns over backwards compatibility
 - full standards-based solution available 2000 (earliest)
-
- Category 7 offers
 - enhanced noise performance and higher frequencies
 - connector war has even not started yet
 - full standards-based solution available 2000 (earliest)

Cable OK, connectors BEWARE

Cable OK, connectors BEWARE



Specification - Optical Fibre

Transmission Equipment

MMF product

- 1st Window
 - lowest cost option (if available)
- 2nd Window
 - lowest cabling attenuation
- determine options for attenuation support
 - determine 50/125 coupling loss

SMF product

- determine return loss requirements
 - impact on maintenance

Cabling Configuration

- difficult to improve connecting hardware
 - minimise no. of connections



Optical Fibre Standards

ANSI/TIA/EIA 568A Optical fibres

62.5/125 μ m
 α : 3.75dB/km (850nm)
 α : 1.75dB/km (1300nm)
B: 160MHzkm (850nm)
B: 500MHzkm (1300nm)
8/125 μ m

ANSI/TIA/EIA 568A Connecting hardware

Mated connection (MMF, SMF)
Installed attenuation (max) = 1.0dB
Return loss (min) = ????

Splice
Attenuation = 0.3dB max.

Telecommunications Outlet
(MMF and SMF)
Green field: SC Duplex

IS 11801 and EN 50173 Optical fibres

62.5/125 μ m or 50/125 μ m
 α : 3.5dB/km (850nm)
 α : 1.0dB/km (1300nm)
B: 200MHzkm (850nm)
B: 500MHzkm (1300nm)
8/125 μ m

IS 11801 and EN 50173 Connecting hardware

Mated connection (MMF, SMF)
Installed attenuation (max) = 0.75dB
Return loss (min) = 20dB MMF, 26dB SMF

Splice
Attenuation = 0.3dB max.

Telecommunications Outlet
(MMF and SMF)
Green field: SC Duplex
Legacy: BFOC/2,5 (ST)



Procurement - Optical Fibre

Optical Fibre

MMF

- revisit automatic selection of 62.5/125
 - 62.5/125 >>> 50/125
 - if equipment supports coupling loss
 - lowest cost equipment option for user
- specify bandwidth
 - chose best option available
 - pending more information on LASER launch bandwidths
 - **NOBODY WILL ENJOY IDENTIFYING BANDWIDTH PROBLEMS**
- 62.5
 - 160/500 >>> 200/500
- 50/125
 - 500/500 >>> 600/800

SMF

- include in campus backbone cabling
- consider as upgrade to building backbone



Procurement - Copper

Balanced pair copper

- what can be specified?
 - Category 5 (1998) represents a benchmark
- what if I want better?
 - agree the specification of the cable
 - ATT, NEXT, FEXT, return loss, delay, skew
 - agree the specification of connecting hardware
 - link
 - channel
 - demand FULL backwards compatibility
- what can be easily verified?
 - performance to 100MHz
- what is future proof?
 - the ability of installed cabling to support evolving applications
 - there may be proprietary applications for Cat. 7
 - standards-based apps
 - migration to OF before Cat. 6 becomes established

enhanced Category 5 products NOW

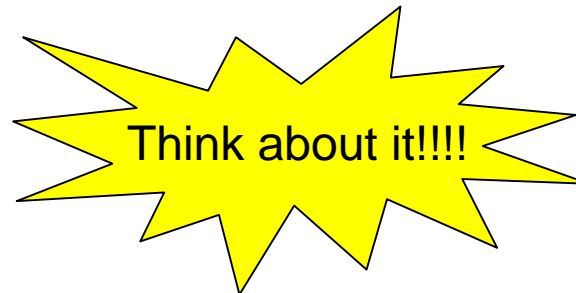
Cat.7 would require a network analyser



The End

A QUESTION TO YOU

In the horizontal
could you install
2 off terminated Category 5 (1998) cables + 4 off dark SM fibres
more cheaply
than 2 off terminated "Category 7" cables?





DATA CABLING - BACK IN THE MELTING POT?

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QUESTIONS