DATA CABLING IN THE MELTING POT
-
The End is Nigh

prepared and delivered

by

The Cabling Partnership

12th March 2001

The Cabling Partnership

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- **Training**
- **Design and specification**
- **Cabling/ IT cost management**
- **Project management**
- **Audits and arbitration**

DATA CABLING IN THE MELTING POT - THE END IS NIGH

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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

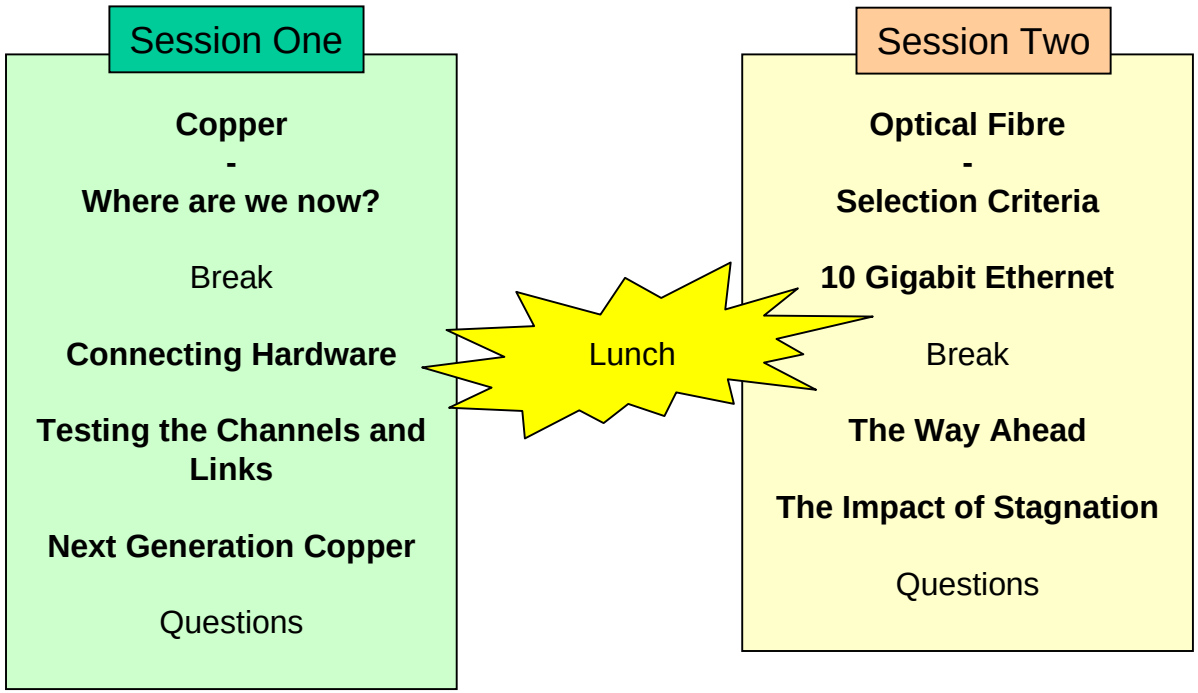
- **ISO/IEC, Member, JTC1 SC25 WG3: Generic Cabling**

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"

Agenda



DATA CABLING IN THE MELTING POT - THE END IS NIGH

Copper - Where are we now?

Session One

Copper
-
Where are we now?

Break

Connecting Hardware

Testing the Channels and Links

Next Generation Copper

Questions

Session Two

Optical Fibre
-
Selection Criteria

10 Gigabit Ethernet

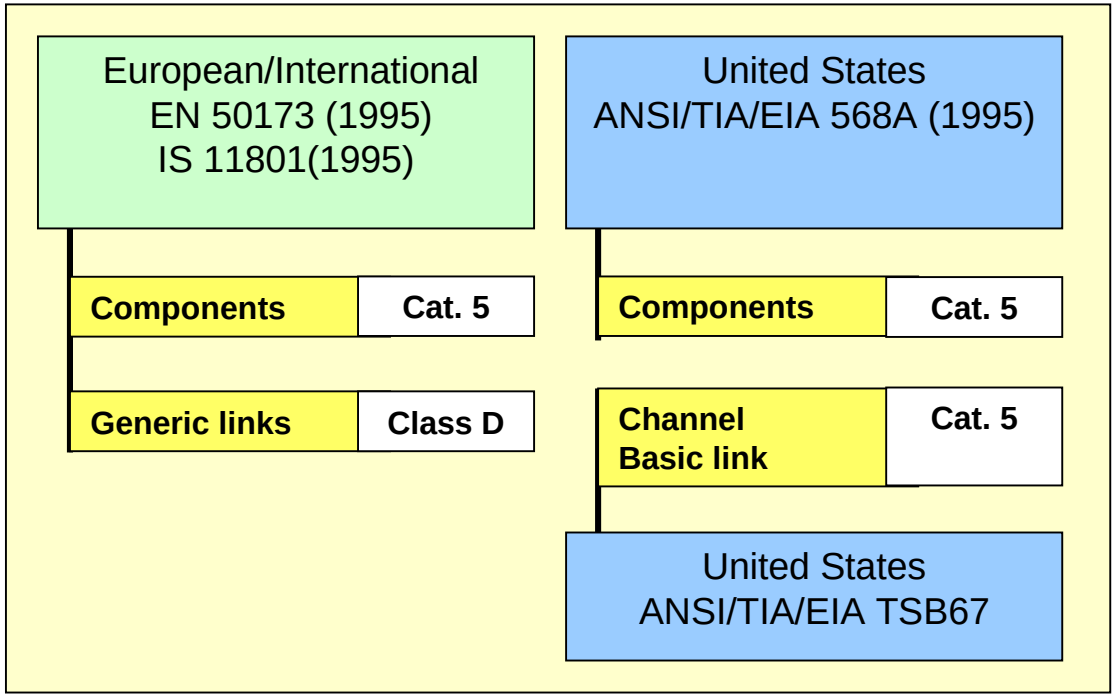
Break

The Way Ahead

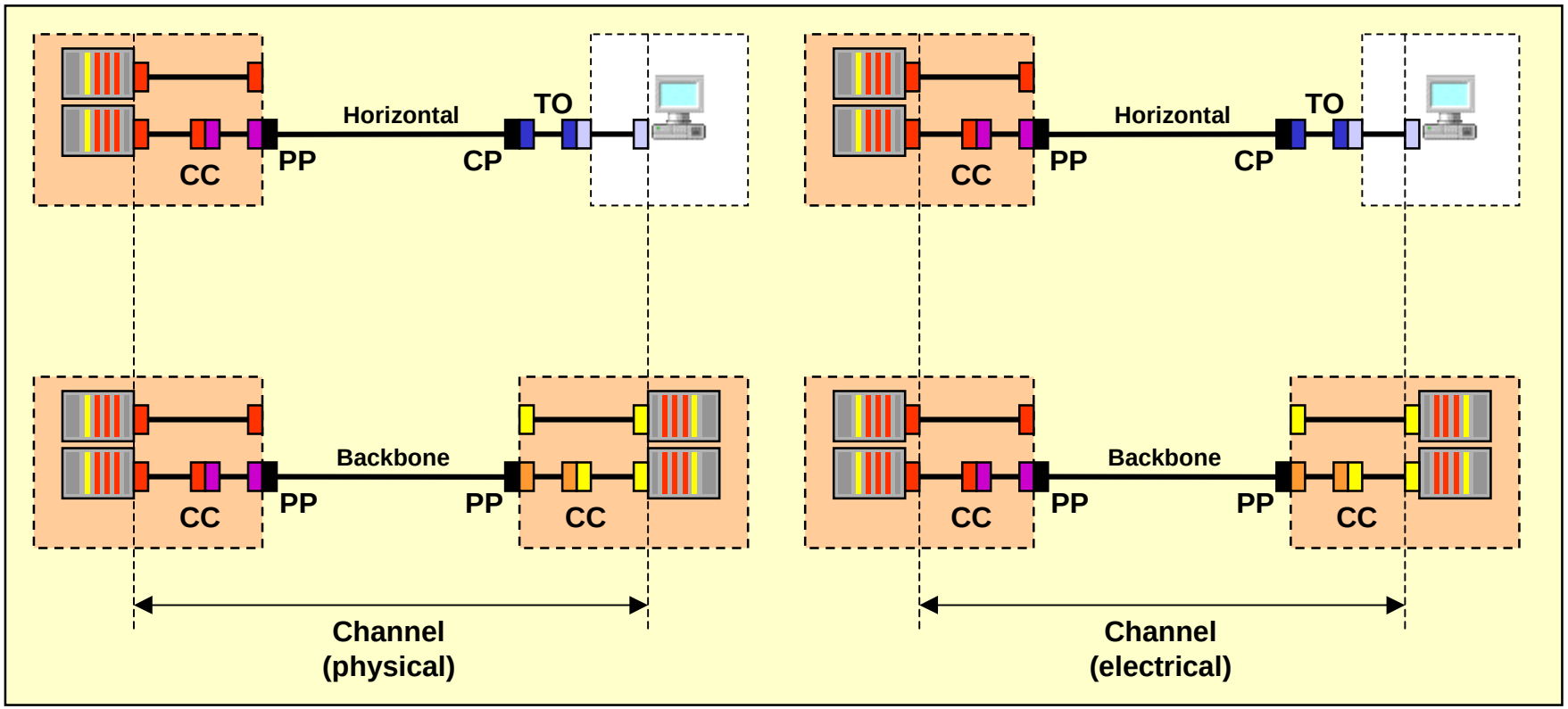
The Impact of Stagnation

Questions

Cabling Design Standards (1995)



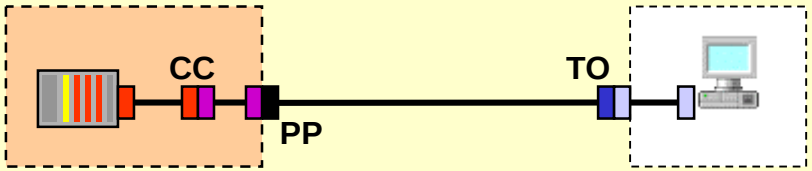
Copper Channels

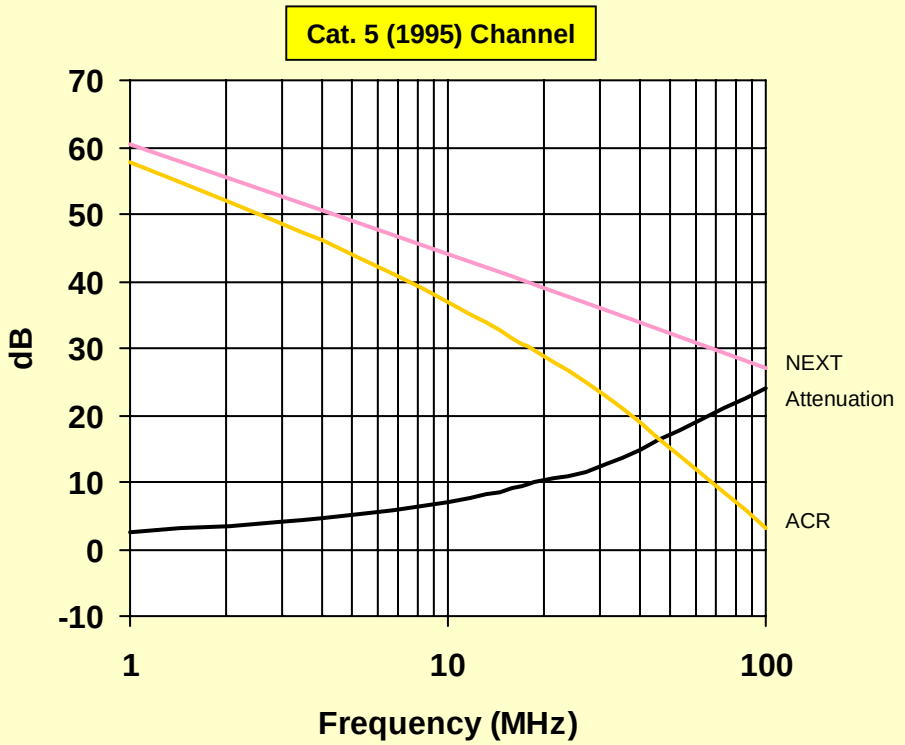


Cat. 5 (1995) Channel

Category 5 (1995) Channel

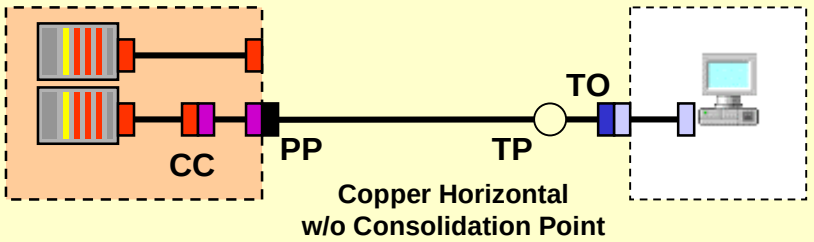
- **based on Category 5 (1995) components**
  - **IS 11801, EN 50173 and 568A**
- **minimal specification**
  - **attenuation, NEXT**
  - **ACR specified by default**
- **design concept**
  - **simplex 2 pair transmission**
  - **3 connectors**
- **risks**
  - **ATM155**



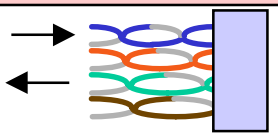


Forces For Change

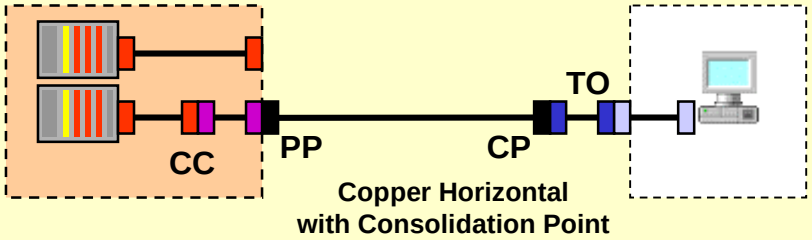
Cat. 5 (1995)



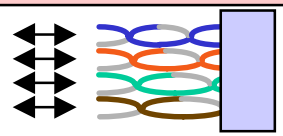
Simple
Simplex Bi-directional transmission



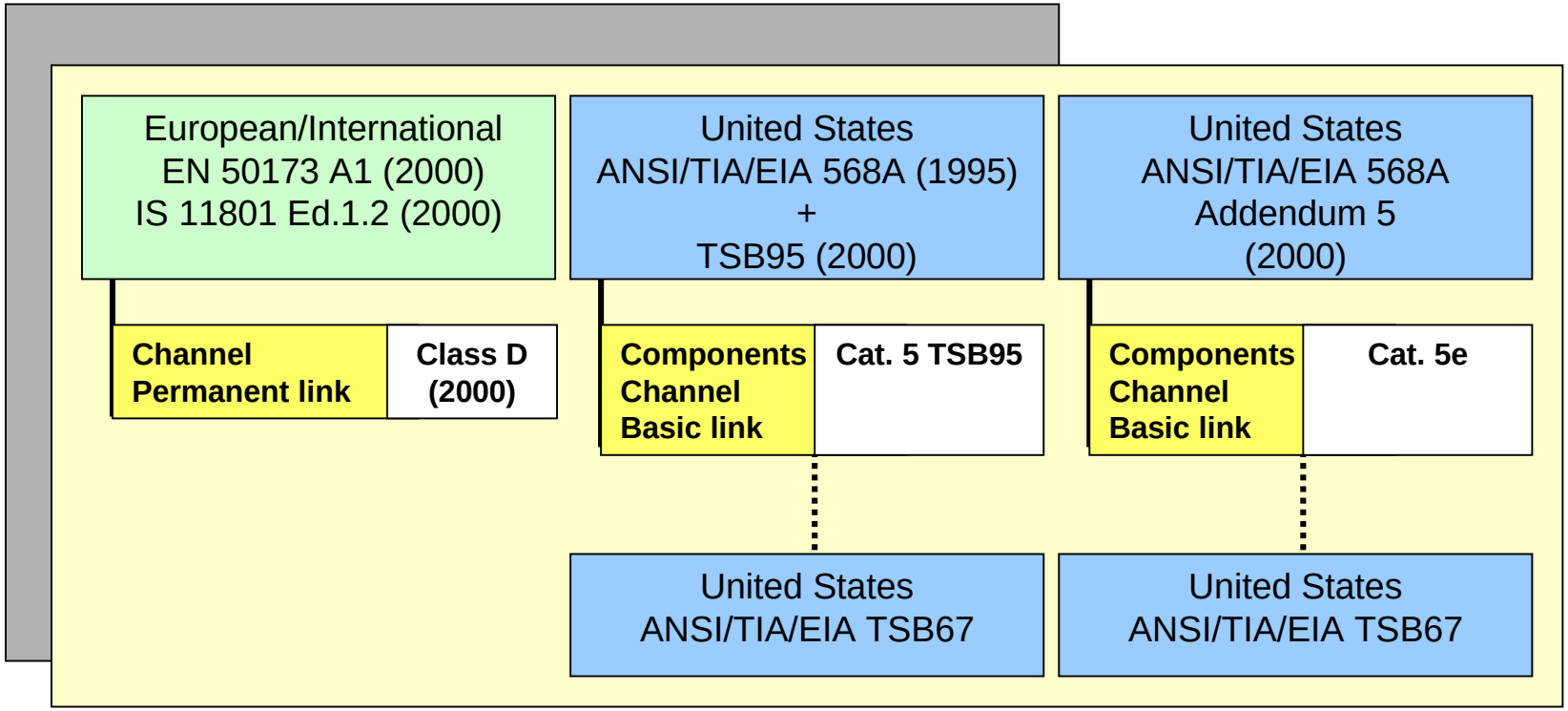
Cat. 5 (TSB95), Class D (2000) and Cat. 5e



Complex
Duplex Bi-directional transmission



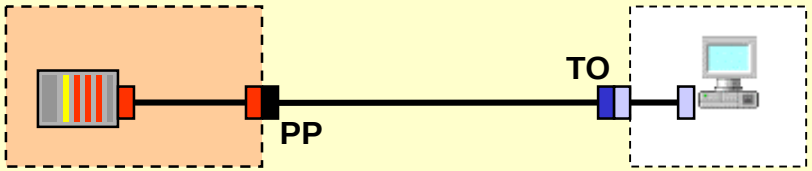
Cabling Design Standards (2000)

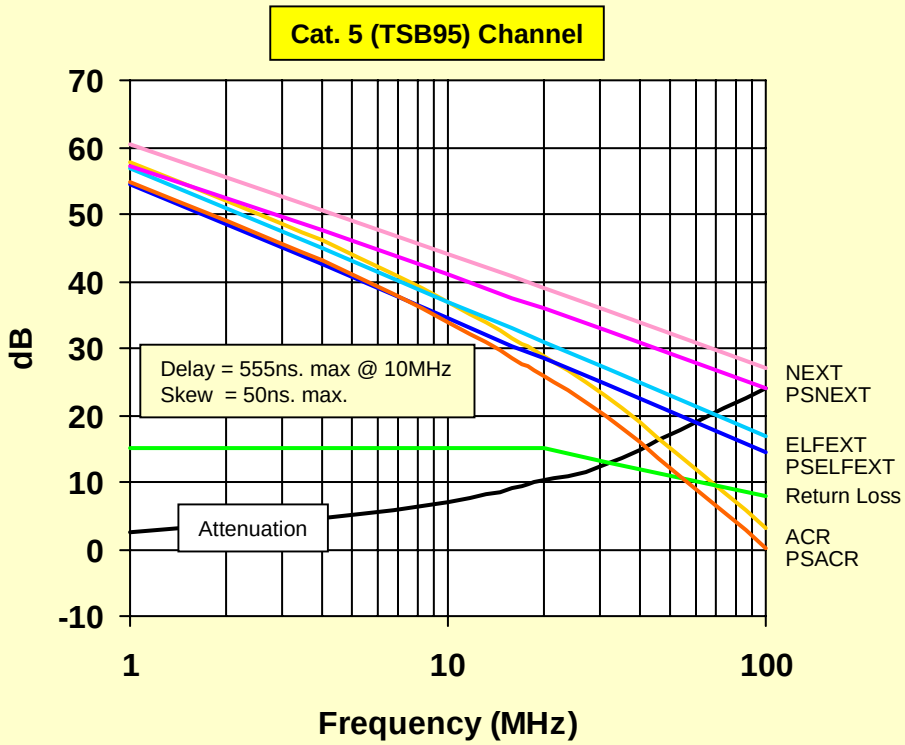


Cat. 5 (TSB95) Channel

Category 5 (TSB95) Channel

- based on TSB95 components
  - Category 5 (1995) components
    - IS 11801, EN 50173 and 568A
  - additional parameters specified
    - ELFEXT, return loss
    - PS parameters
    - delay, delay skew
- design concept
  - full duplex 4 pair transmission
  - 2 connectors
  - 1000BASE-T

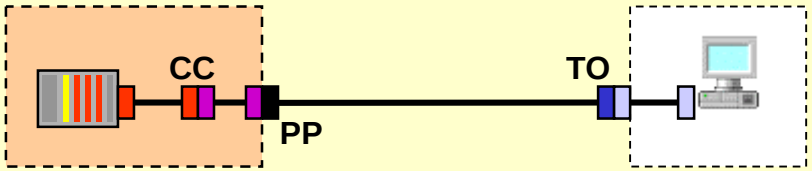


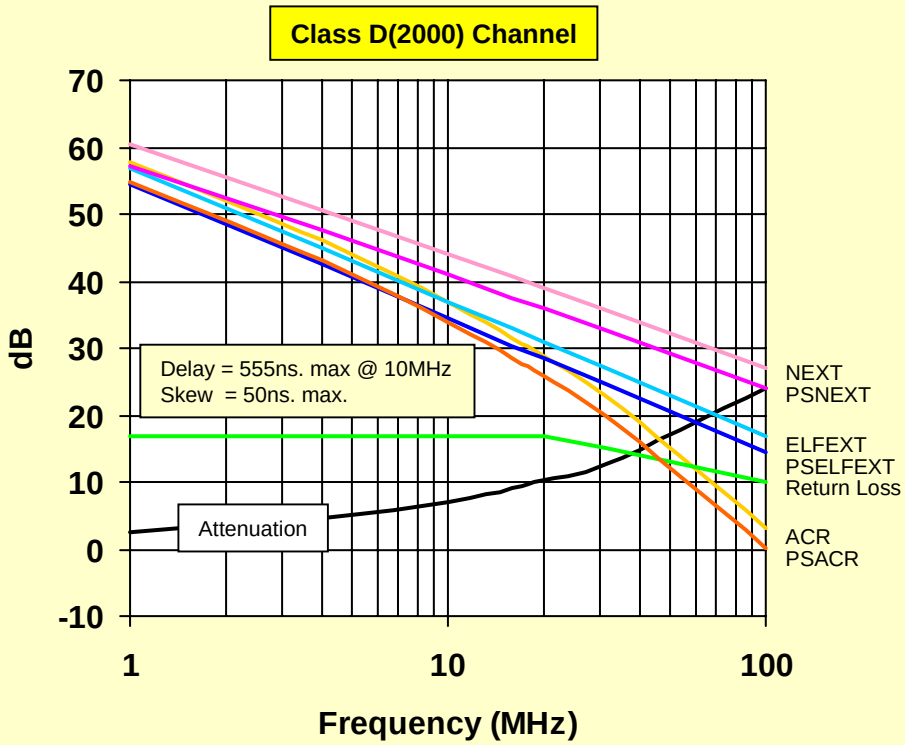


Class D (2000) Channel

Class D (2000) Channel

- **installed requirement only**
- **design concept**
  - **full duplex 4 pair transmission**
  - **2 or 3 connectors (CP not included)**
  - **1000BASE-T**
- **no components specified**
  - **Cat. 5 (TSB95) for 2 connector channel**
  - **Cat. 5e for 3 connector channel**

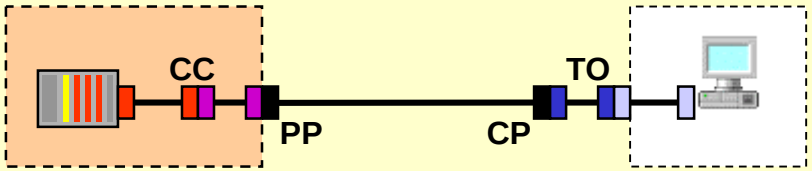


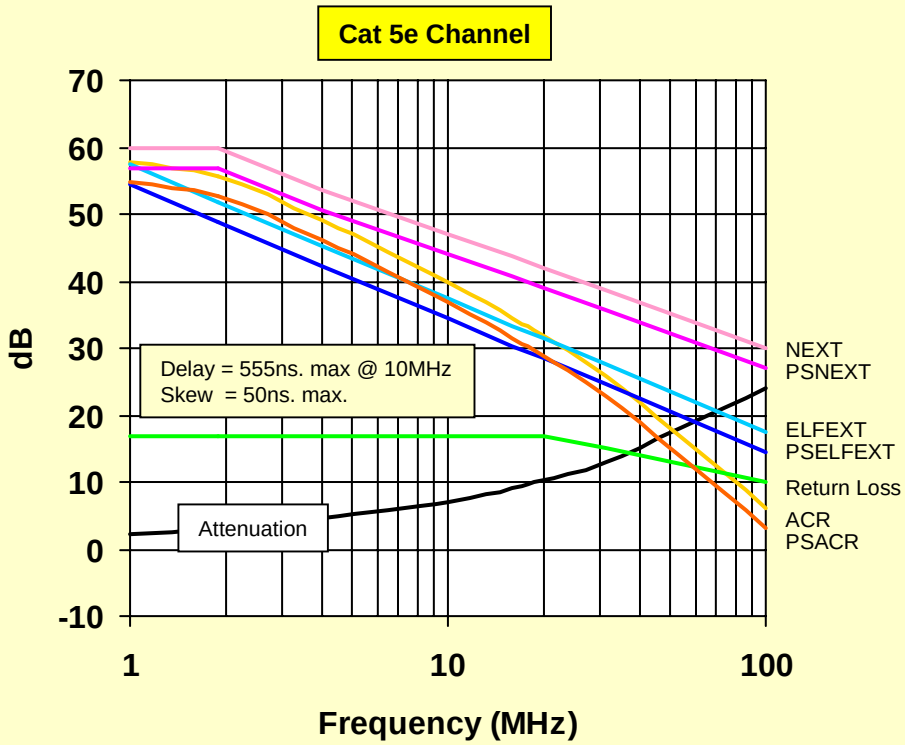


Cat. 5e Channel

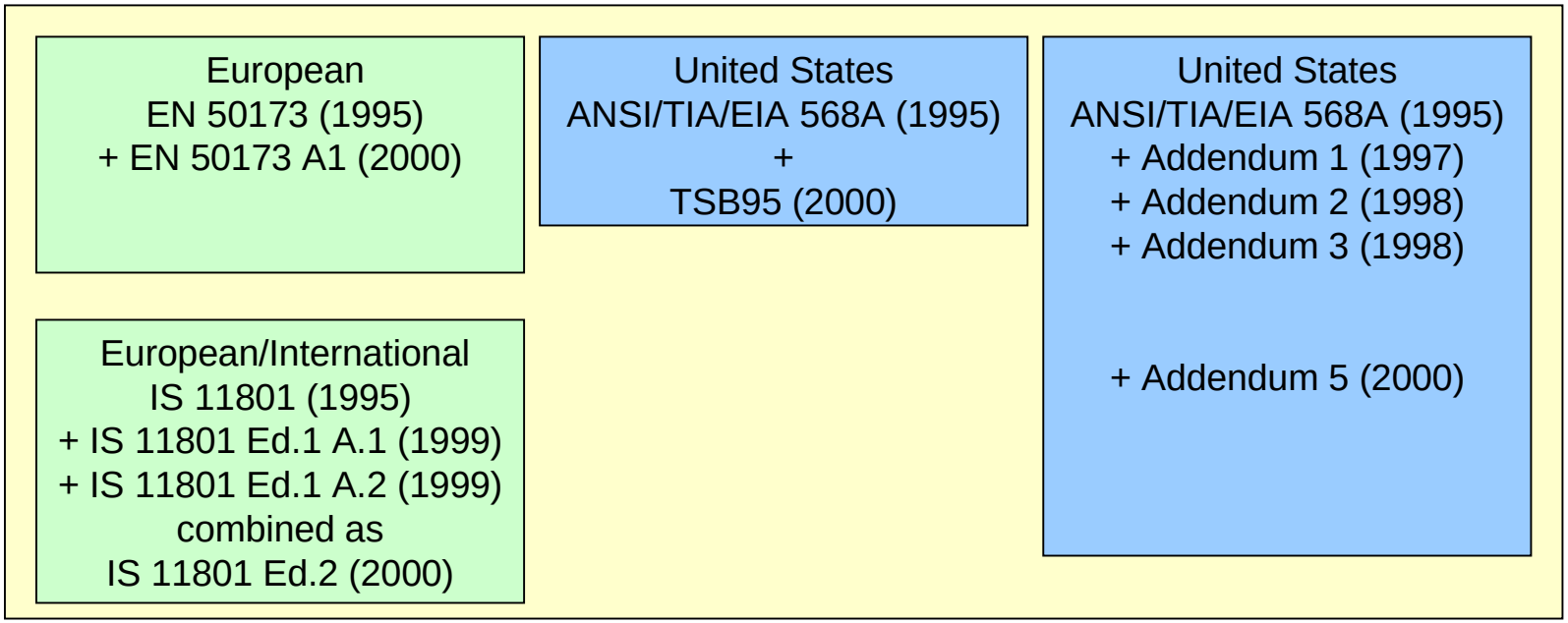
Cat. 5e Channel

- based on Cat. 5e components
- performance upgrade from Cat. 5 (TSB95)
  - ~3dB NEXT, PSNEXT, ACR and PSACR
  - ~0.4dB ELFEXT
  - 2dB on return loss
- performance upgrade from Class D (2000)
  - ~3dB NEXT, PSNEXT, ACR and PSACR
  - ~0.4dB ELFEXT
- design concept
  - full duplex 4 pair transmission
  - 4 connectors
  - 1000BASE-T support with margin
    - 2dB return loss

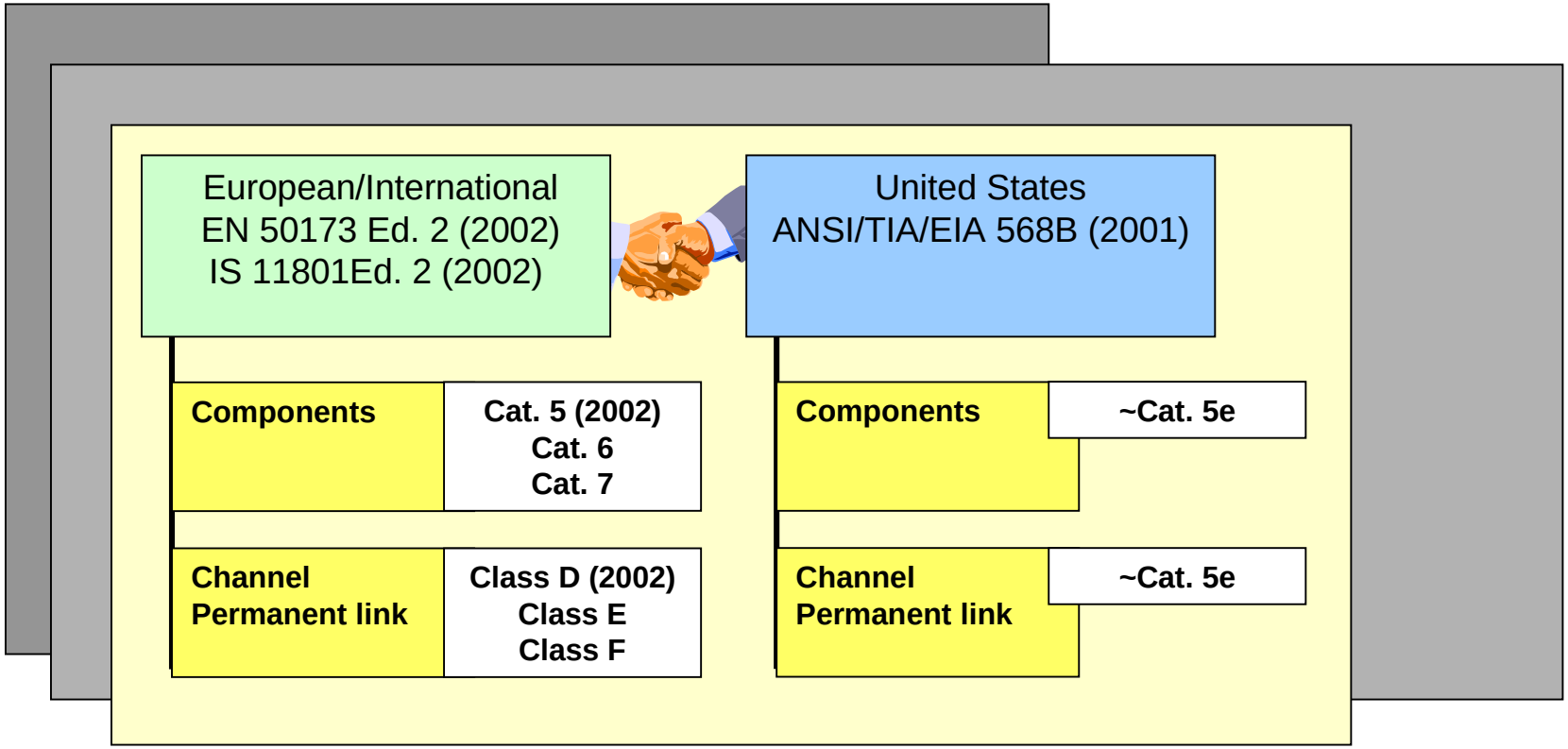




Standards Status



The Future



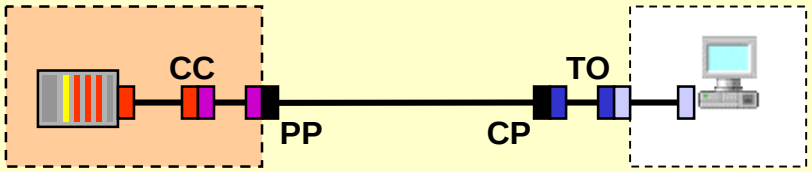
Class D (2002) Channel Equations

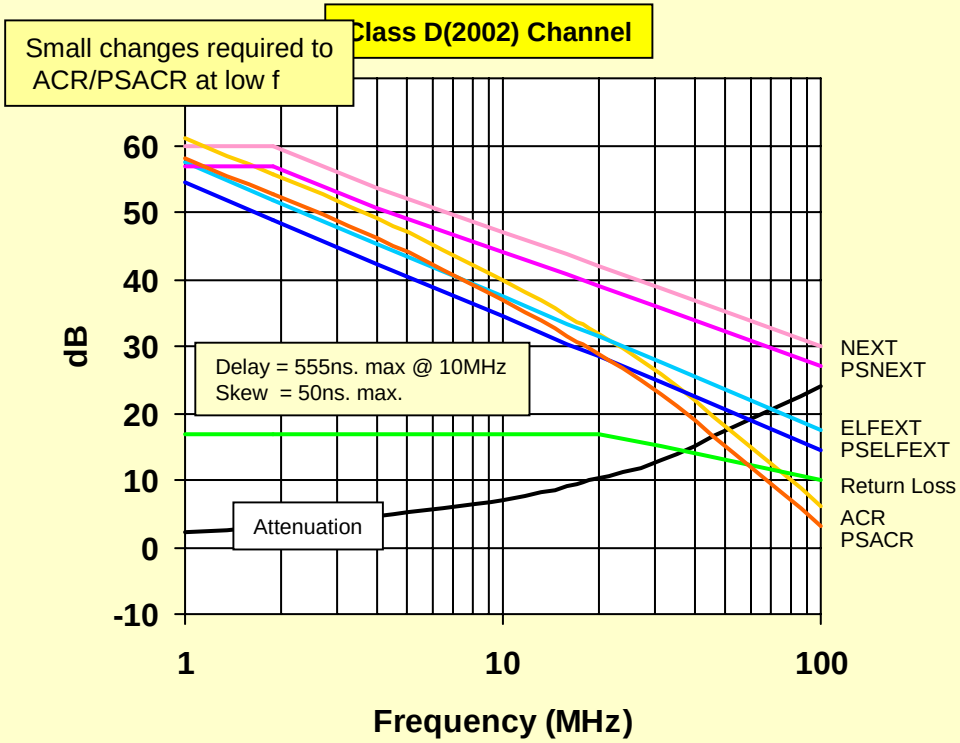
Parameter	Frequency	Channel formulae
Attenuation (dB max.)	1 ≤ f ≤ 100	1.05 x (1.9108Sf+0.0222f+0.2/Sf) + 4x0.04Sf, 4 dB min.
NEXT (dB min.)	1 ≤ f ≤ 100	$-20 \log(10^{-0.05(65.3-15\log(f))} + 2x10^{-0.05(83-20\log(f))})$, 60 dB max.
PSNEXT (dB min.)	1 ≤ f ≤ 100	$-20 \log(10^{-0.05(62.3-15\log(f))} + 2x10^{-0.05(80-20\log(f))})$, 57 dB max.
ACR (dB min.)	1 ≤ f ≤ 100	NEXT - attenuation
PSACR (dB min.)	1 ≤ f ≤ 100	PSNEXT - attenuation
ELFEXT (dB min.)	1 ≤ f ≤ 100	$-20 \log(10^{-0.05(63.8-20\log(f))} + 4x10^{-0.05(75.1-20\log(f))})$, 60 dB max.
PSELFEXT (dB min.)	1 ≤ f ≤ 100	$-20 \log(10^{-0.05(60.8-20\log(f))} + 4x10^{-0.05(72.1-20\log(f))})$, 57 dB max.
Return loss (dB min.)	1 ≤ f ≤ 100	30-10log(f), 17.0 dB max.
Prop. Delay (µs max.)	1 ≤ f ≤ 100	0.534 +0.036Sf + 4x0.0025
Skew (µs max.)	1 ≤ f ≤ 100	0.045 + 4x0.0025 = 0.050

Class D (2002) Channel

Class D (2002) Channel

- **identical to Cat. 5e channel**
- **PSACR = 0dB at 125MHz (derived)**





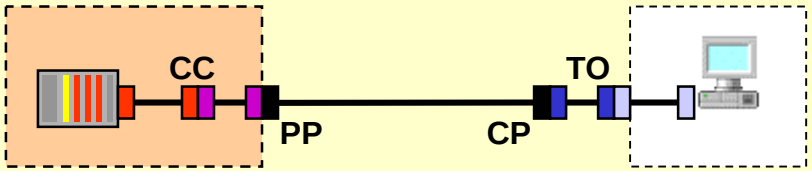
Class E Channel Equations

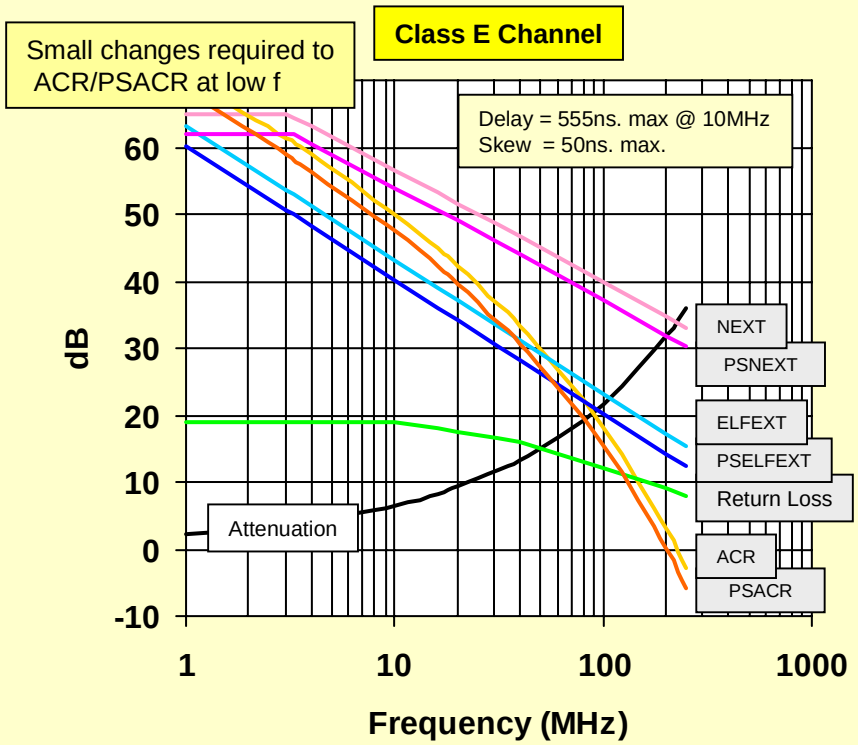
Parameter	Frequency	Channel formulae
Attenuation (dB max.)	1 ≤ f ≤ 250	1.05 x (1.82Sf+0.0169f+0.25/Sf) + 4x0.02Sf, 4 dB min.
NEXT (dB min.)	1 ≤ f ≤ 250	$-20 \log(10^{-0.05(74.3-15\log(f))} + 2x10^{-0.05(94-20\log(f))})$, 65 dB max.
PSNEXT (dB min.)	1 ≤ f ≤ 250	$-20 \log(10^{-0.05(72.3-15\log(f))} + 2x10^{-0.05(90-20\log(f))})$, 62 dB max.
ACR (dB min.)	1 ≤ f ≤ 250	NEXT - attenuation
PSACR (dB min.)	1 ≤ f ≤ 250	PSNEXT - attenuation
ELFEXT (dB min.)	1 ≤ f ≤ 250	$-20 \log(10^{-0.05(67.8-20\log(f))} + 4x10^{-0.05(83.1-20\log(f))})$, 65 dB max.
PSELFEXT (dB min.)	1 ≤ f ≤ 250	$-20 \log(10^{-0.05(64.8-20\log(f))} + 4x10^{-0.05(80.1-20\log(f))})$, 62 dB max.
Return loss (dB min.)	1 ≤ f ≤ 40 40 ≤ f ≤ 250	24-5log(f), 19.0 dB max. 32-10log(f)
Prop. Delay (µs max.)	1 ≤ f ≤ 250	0.534 +0.036Sf + 4x0.0025
Skew (µs max.)	1 ≤ f ≤ 250	0.045 + 4x0.0025 = 0.050

Class E Channel

Class E Channel

- **performance upgrade over Class D (2002)**
  - **2.3dB$^{@100MHz}$ Attenuation (~10%)**
  - **9.8dB NEXT, 10dB PSNEXT**
  - **5.8dB ELFEXT, PSELFEXT**
  - **~2dB return loss**
- **PSACR = 0dB at 200MHz**
- **specified up to 250MHz**





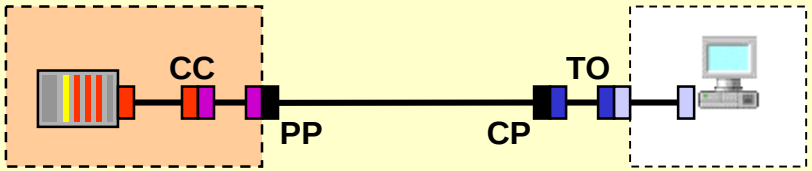
Class F Channel Equations

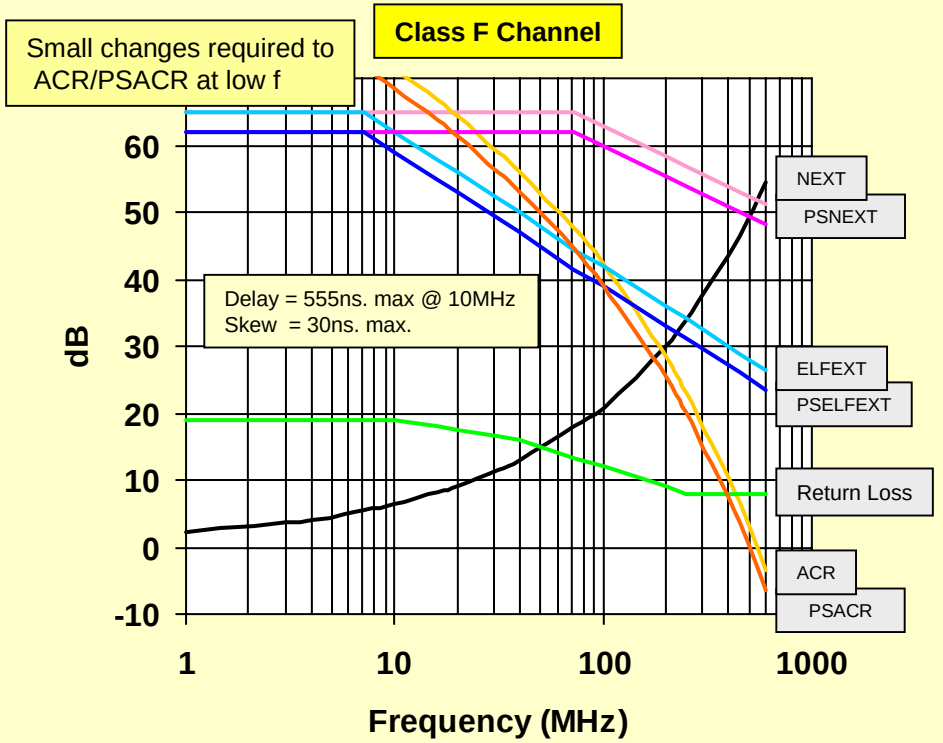
Parameter	Frequency	Channel formulae
Attenuation (dB max.)	$1 \le f \le 600$	1.05 x (1.8Sf+0.01f+0.2/Sf) + 4x0.02Sf, 4 dB min.
NEXT (dB min.)	$1 \le f \le 600$	$-20 \log(10^{-0.05(102.4-15\log(f))} + 2x10^{-0.05(102.4-15\log(f))})$, 65 dB max.
PSNEXT (dB min.)	$1 \le f \le 600$	$-20 \log(10^{-0.05(99.4-15\log(f))} + 2x10^{-0.05(99.4-15\log(f))})$, 62 dB max.
ACR (dB min.)	$1 \le f \le 600$	NEXT - attenuation
PSACR (dB min.)	$1 \le f \le 600$	PSNEXT - attenuation
ELFEXT (dB min.)	$1 \le f \le 600$	$-20 \log(10^{-0.05(94-20\log(f))} + 4x10^{-0.05(90-15\log(f))})$, 65 dB max.
PSELFEXT (dB min.)	$1 \le f \le 600$	$-20 \log(10^{-0.05(91-20\log(f))} + 4x10^{-0.05(87-15\log(f))})$, 62 dB max.
Return loss (dB min.)	$1 \le f \le 40$ $40 \le f \le 600$	24-5log(f), 19.0 dB max. 32-10log(f), 8.0dB min.
Prop. Delay (µs max.)	$1 \le f \le 600$	0.534 +0.036Sf + 4x0.0025
Skew (µs max.)	$1 \le f \le 600$	0.025 + 4x0.0025 = 0.030

Class F Channel

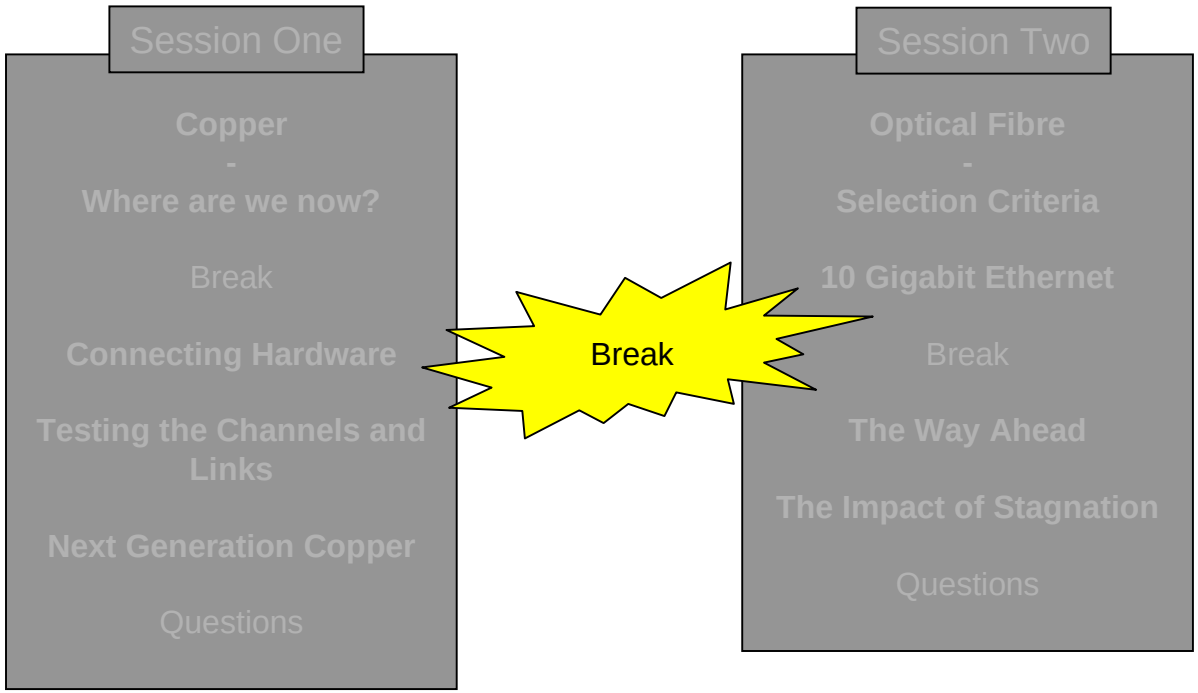
Class F Channel

- **performance upgrade over Class D (2002)**
  - **3.2dB$^{@100MHz}$ Attenuation (~13%)**
  - **32.8dB NEXT, PSNEXT**
  - **24.6dB ELFEXT, PSELFEXT**
  - **~2dB return loss**
  - **20ns delay skew (RGB?)**
- **performance upgrade over Class E**
  - **0.9dB$^{@100MHz}$ Attenuation (~4%)**
  - **23dB NEXT, 22.8dB PSNEXT**
  - **18.8dB ELFEXT, PSELFEXT**
  - **20ns delay skew (RGB?)**
- **PSACR = 0dB at 501MHz**





Agenda



Connecting Hardware

Session One

- **Copper - Where are we now?**
- Break
- **Connecting Hardware**
- **Testing the Channels and Links**
- **Next Generation Copper**
- Questions

Session Two

- **Optical Fibre - Selection Criteria**
- **10 Gigabit Ethernet**
- Break
- **The Way Ahead**
- **The Impact of Stagnation**
- Questions

Connecting Hardware

IS 11801 Ed.2 (CDV) EN 50173 Ed.2 (SE)

Mating dimensions and gauging of TO connection

		IEC TC48	
Category 5	Screened	IEC 60603-7-3	
	Unscreened	IEC 60603-7-2	
Category 6	Screened	IEC 60603-7-5	
	Unscreened	IEC 60603-7-4	
Category 7	Screened	Primary	Back-up
		IEC 60603-7-7	IEC 61076[1]

Cable termination requirements

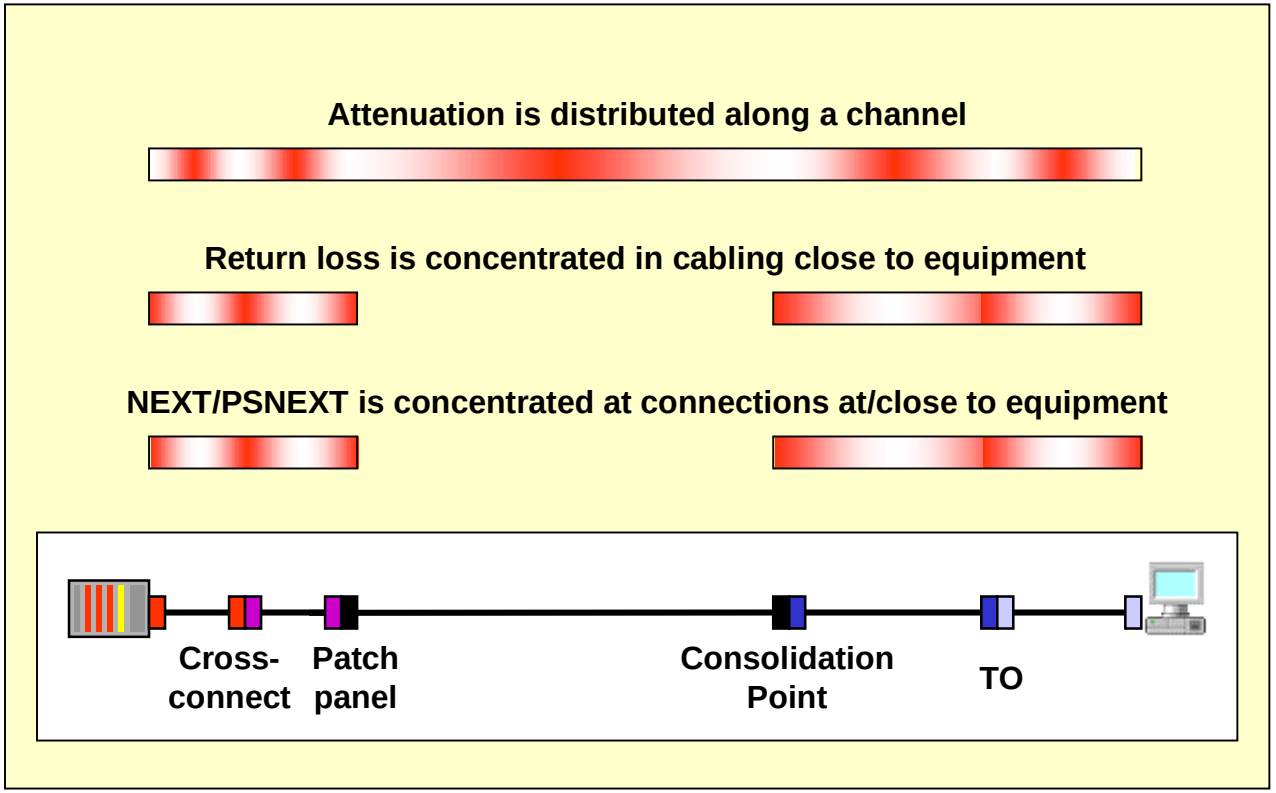
Mechanical durability requirements

Transmission performance requirements

		IEC TC48	
Category 5	Screened	IEC 60603-7-3	
	Unscreened	IEC 60603-7-2	
Category 6	Screened	IEC 60603-7-5	
	Unscreened	IEC 60603-7-4	
Category 7	Screened	Primary	Back-up
		IEC 60603-7-7	IEC 61076[1]

Note 1: a selection has to be made before FDIS (for IS) and 3MV (for EN)

The Importance of Connectors



The Real World - Sockets and Plugs

Non-interoperability

• standards do not guarantee electrical (or even physical) performance of an open system joint
"pending resolution of this guarantees shall be sought from manufacturers"

Backwards incompatibility

• as Category increases, there is no guarantee of backwards compatibility of an open system joint
"Cat. 6 with Cat. 5 may perform below Cat. 5"

Screen continuity/performance

• no agreed standard or specification for inter-component screen connection

The Real World - Cords

Standards

• there are as yet, no standards for cable assemblies (terminated plugs)
"when they arrive they may dis-enfranchise the installed base"

Production tolerances

• variations in termination process may have to be improved
"differences in 0.5-1.0mm of untwisted length have a major impact"

Handling

• as Category increases, so does the sensitivity of patch cords to handling"

Length and temperature

• stranded conductors have higher attenuation than solid conductors
"uncontrolled use of long lead at high temperatures can have dramatic effects"

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Testing the Channels and Links

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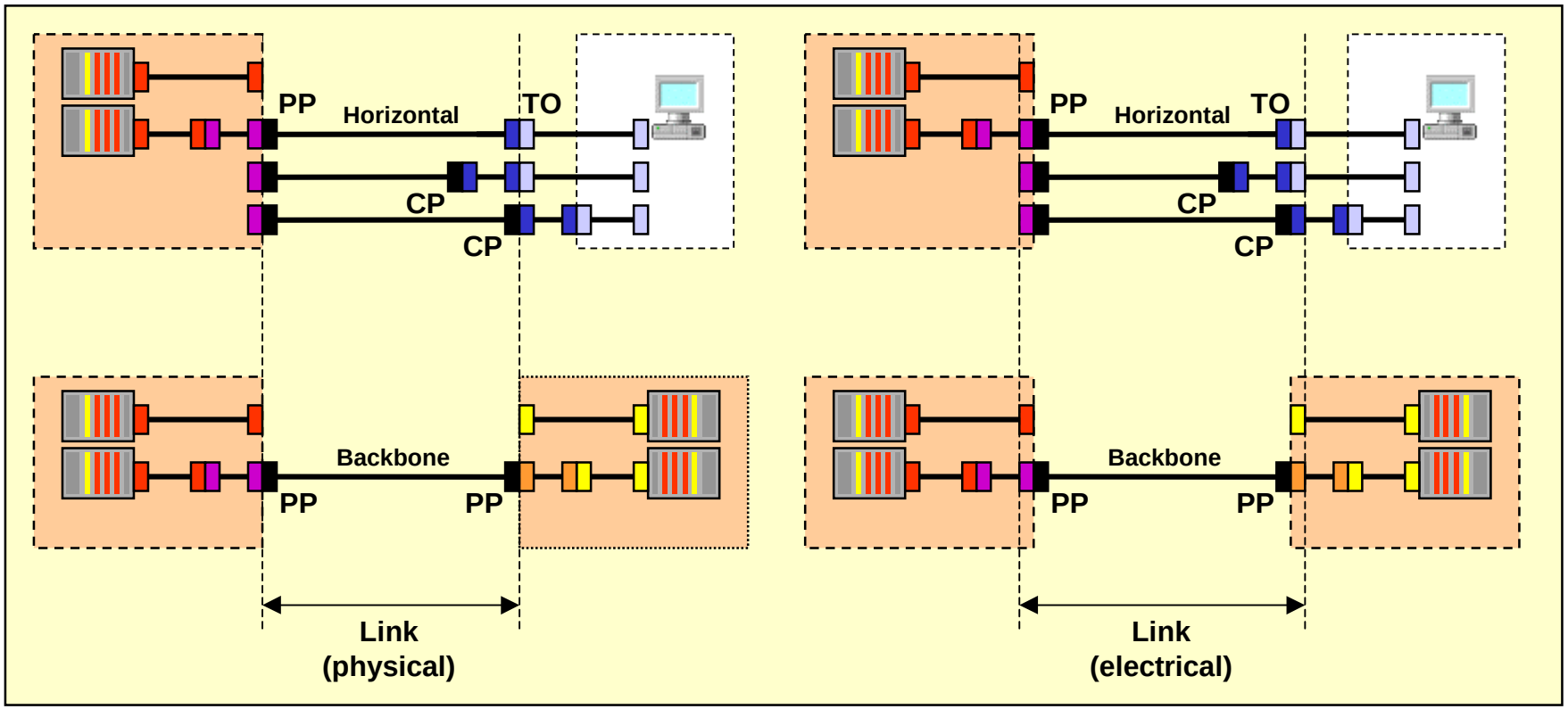
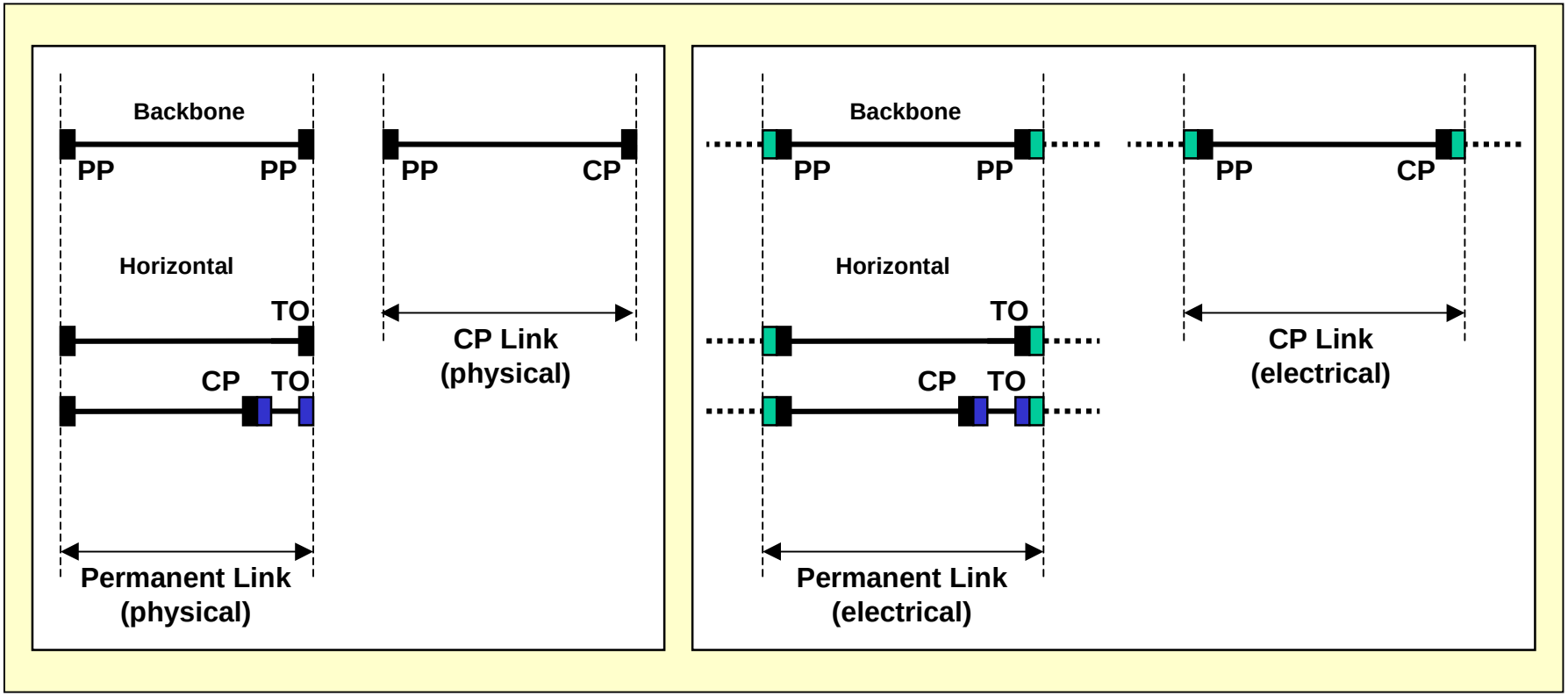
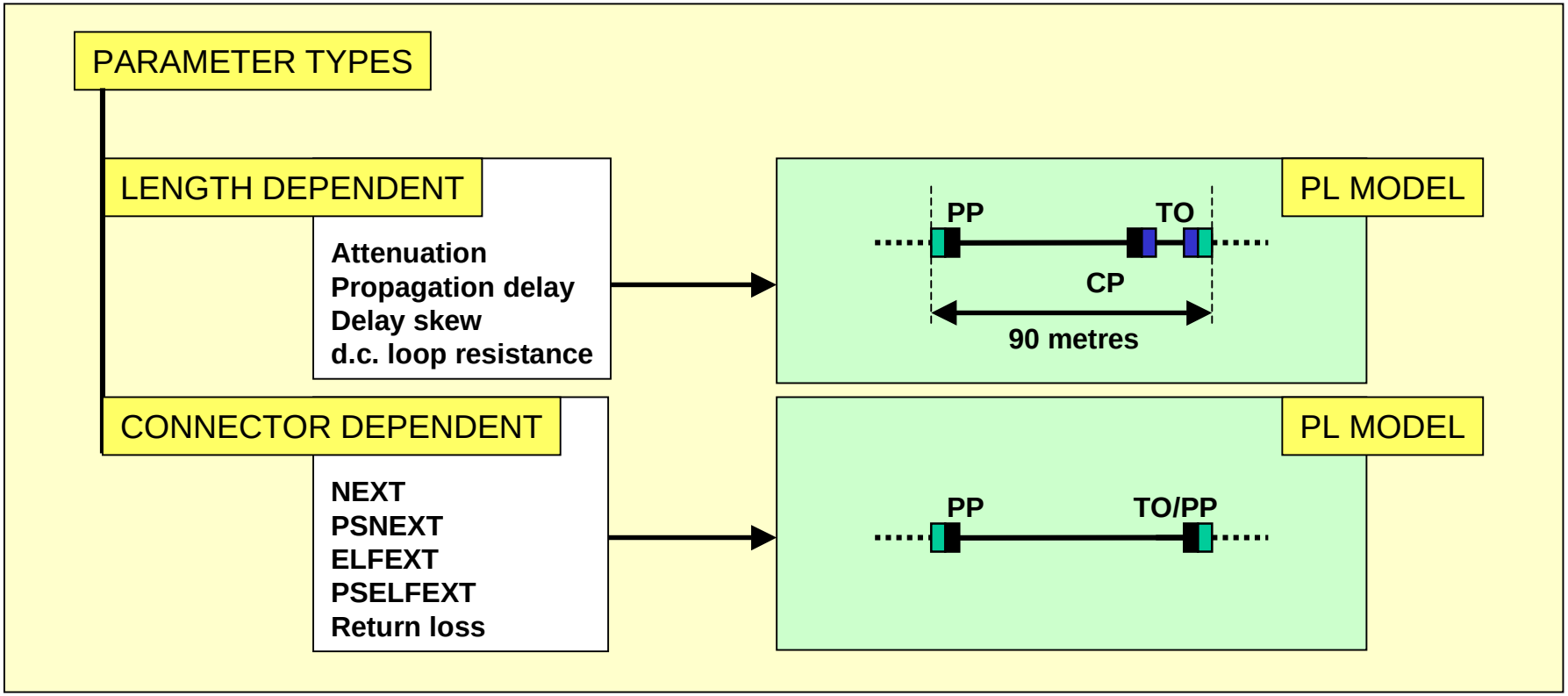
Copper Links



“Permanent Links” and “CP Links”



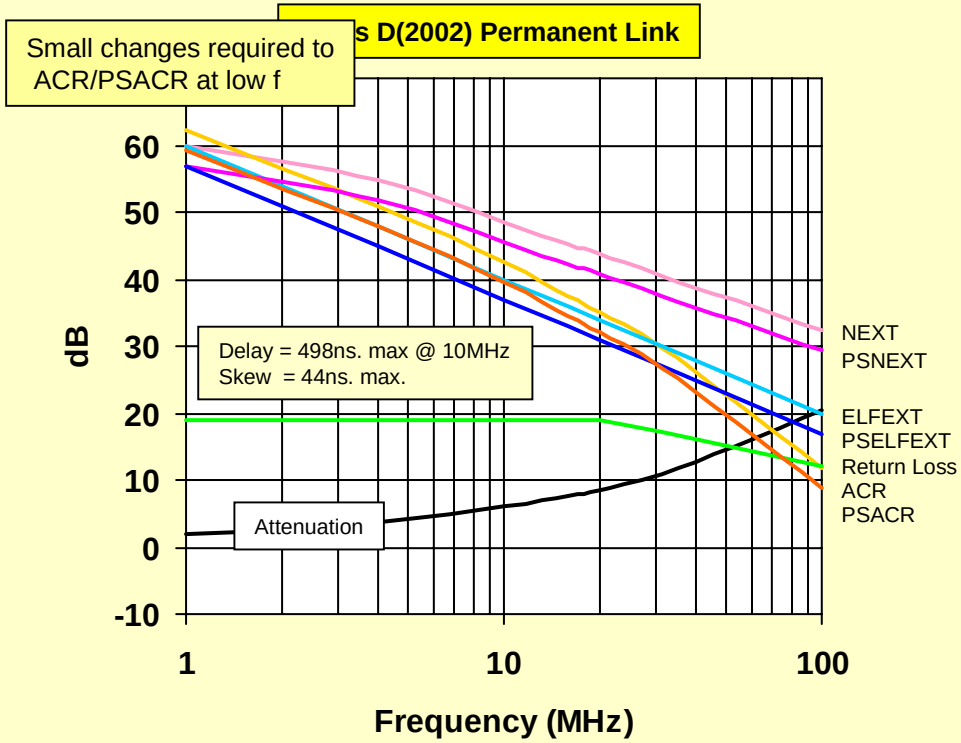
Permanent Link Limits



Class D (2002) Permanent Link

Class D (2002) Permanent Link

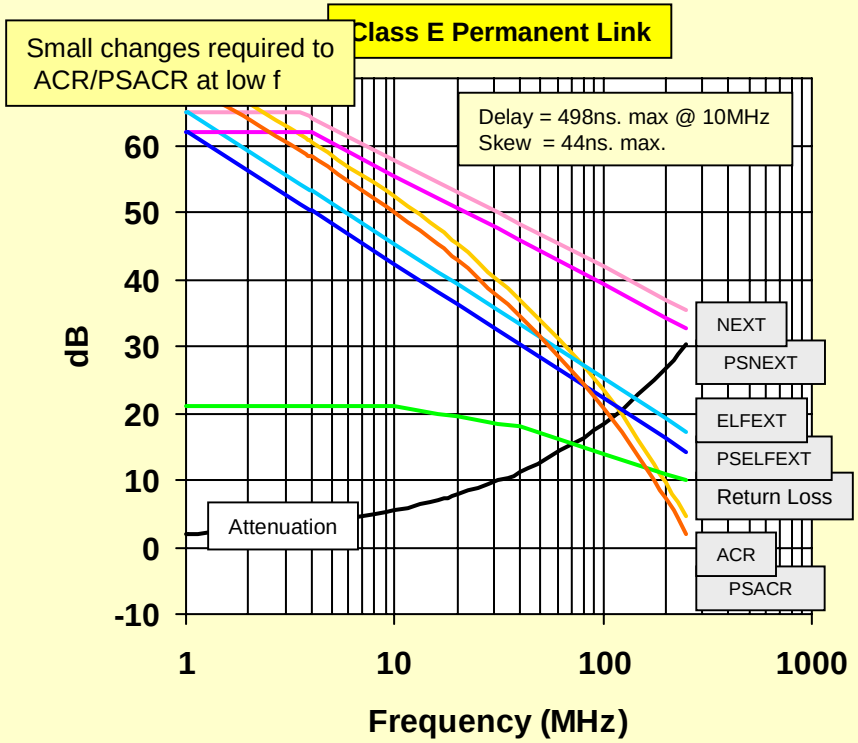
- **attenuation values below 4dB**
  - **information only**
- **return loss values where attenuation < 3dB**
  - **information only**
  - **also applies to channels**
- **NEXT values where attenuation < 4dB**
  - **conform to ACR requirements**
  - **also applies to channels**
- **PSNEXT values where attenuation < 4dB**
  - **conform to PSACR requirements**
  - **also applies to channels**



Class E Permanent Link

Class E Permanent Link

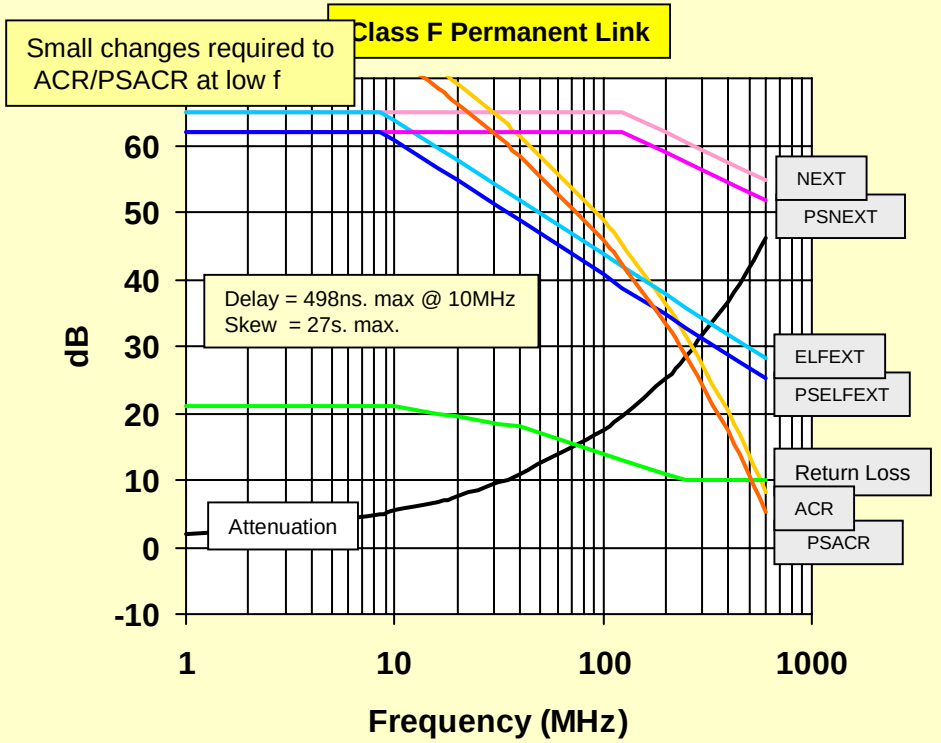
- **attenuation values below 4dB**
  - **information only**
- **return loss values where attenuation < 3dB**
  - **information only**
  - **also applies to channels**
- **NEXT values where attenuation < 4dB**
  - **conform to ACR requirements**
  - **also applies to channels**
- **PSNEXT values where attenuation < 4dB**
  - **conform to PSACR requirements**
  - **also applies to channels**



Class F Permanent Link

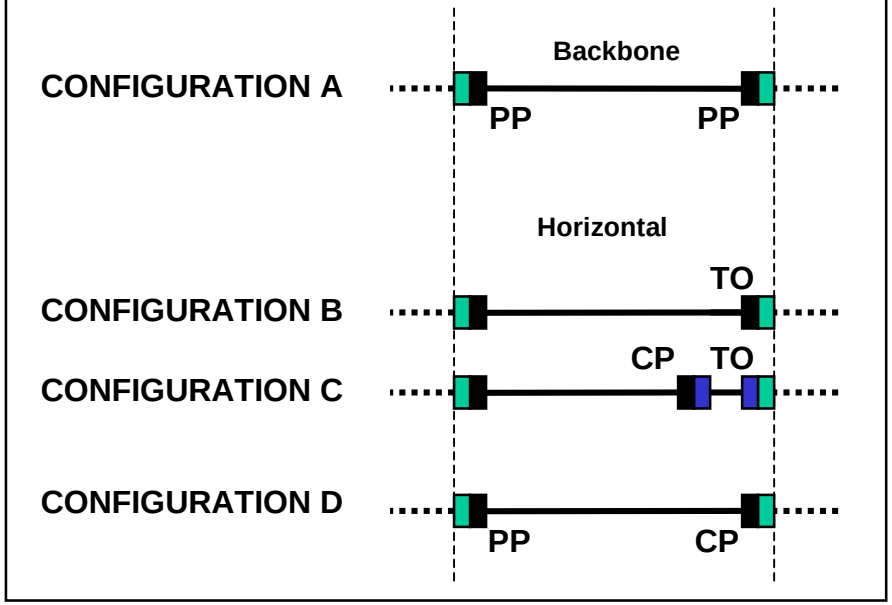
Class F Permanent Link

- **attenuation values below 4dB**
  - **information only**
- **return loss values where attenuation < 3dB**
  - **information only**
  - **also applies to channels**
- **NEXT values where attenuation < 4dB**
  - **conform to ACR requirements**
  - **also applies to channels**
- **PSNEXT values where attenuation < 4dB**
  - **conform to PSACR requirements**
  - **also applies to channels**



Application Of PL Limits

LINK UNDER TEST



RULES

Length dependent parameters
- **all configurations must meet PL limits**
- **Configuration A, B and C must be design consistent**
- **Configuration D must also meet CP Link rules**

Connector dependent parameters
- **all configurations must meet PL limits except**
  - **for low attenuation links**
    - **return loss, NEXT and PSNEXT**
  - **for Configuration C at TO**
    - **return loss, NEXT and PSNEXT**

CP Link Limits

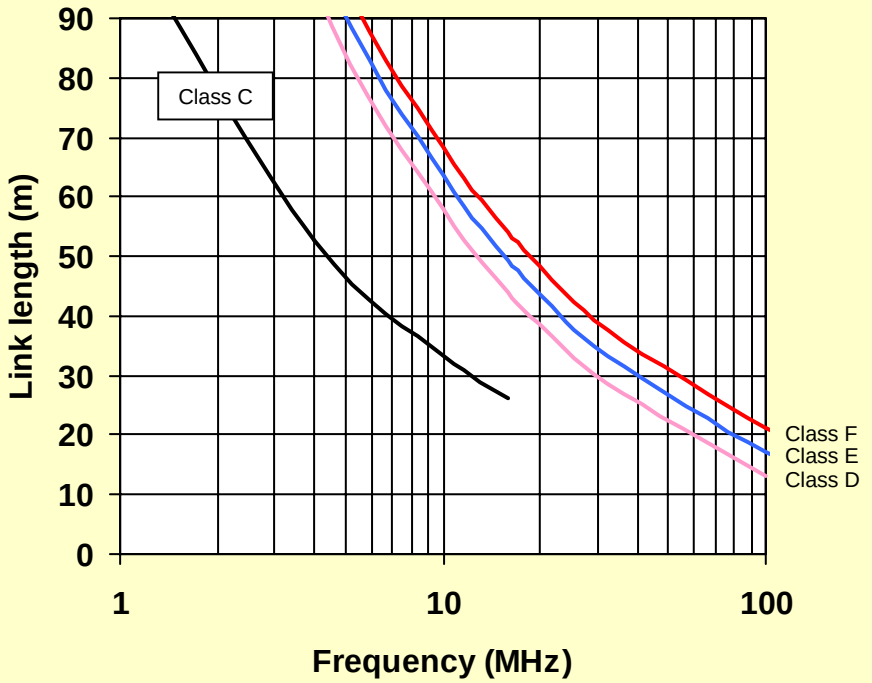
Parameter	Class	Frequency	Channel formulae
Attenuation (dB max.)	D	1 ≤ f ≤ 100	L/100 x (1.9108Sf+0.0222f+0.2/Sf) + 2x0.02Sf
	E	1 ≤ f ≤ 250	L/100 x (1.82Sf+0.0169f+0.25/Sf) + 2x0.02Sf
	F	1 ≤ f ≤ 600	L/100 x (1.8Sf+0.01f+0.2/Sf) + 2x0.02Sf
Prop. Delay (µs max.)	D	1 ≤ f ≤ 100	L/100 x (0.534 +0.036Sf) + 2x0.0025
	E	1 ≤ f ≤ 250	
	F	1 ≤ f ≤ 600	
Skew (µs max.)	D	1 ≤ f ≤ 100	L/100 x (0.045) + 2x0.0025
	E	1 ≤ f ≤ 250	
	F	1 ≤ f ≤ 600	L/100 x (0.025) + 2x0.0025

4dB Link Exclusion

Link attenuation < 4dB

Approximate conditions
- **lengths below 15m @ 100MHz**
- **lengths below 30m @ 31.25MHz**
- **lengths below 40m @ 20MHz**
- **lengths below 55m @ 10MHz**

Rule
- **NEXT/PSNEXT reverts to ACR/PSACR**

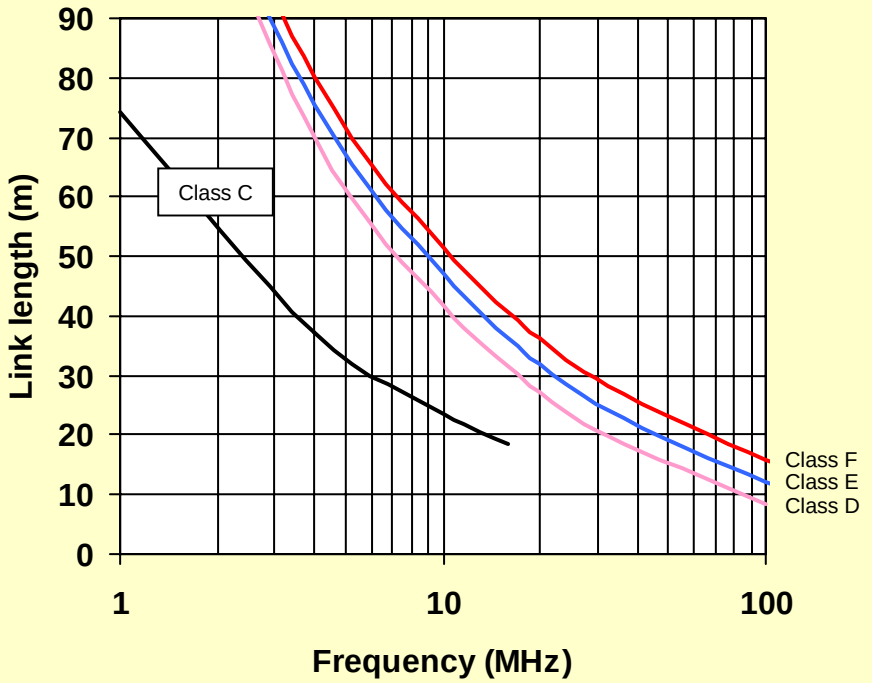


3dB Link Exclusion

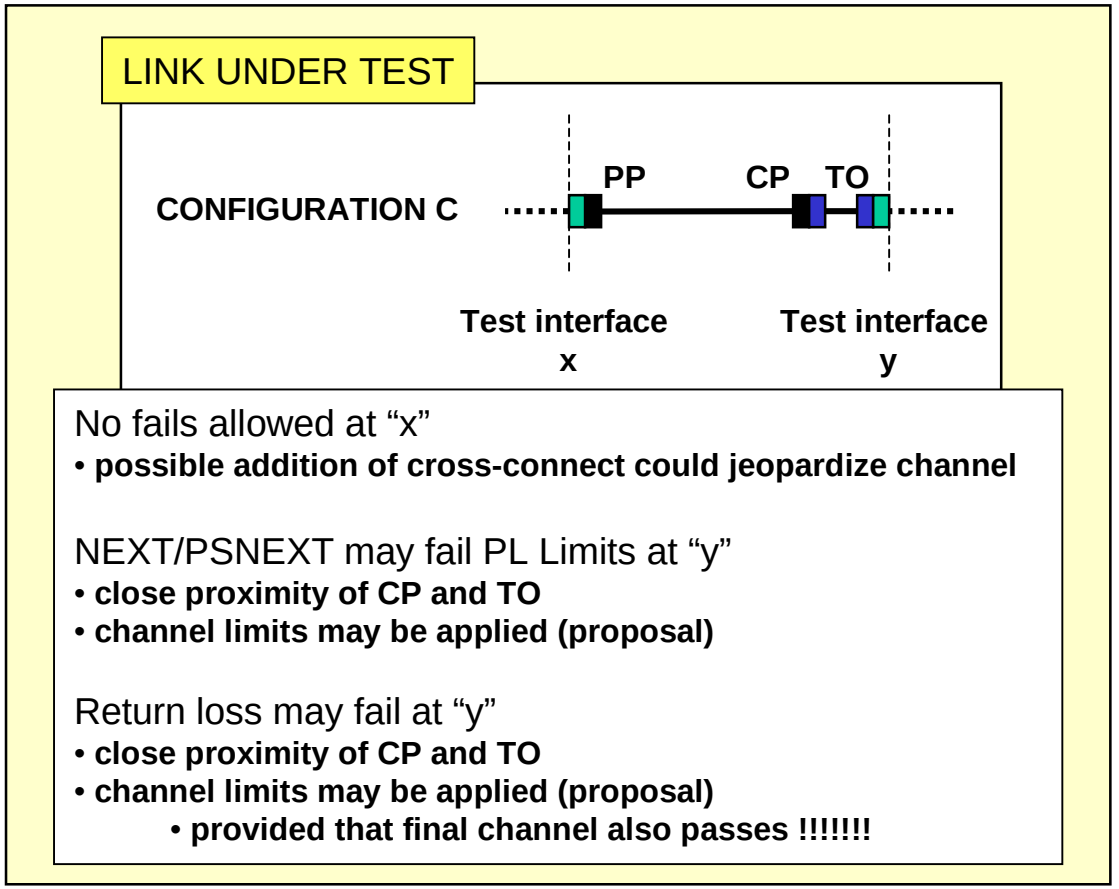
Link attenuation < 3dB

Approximate conditions
- **lengths below 10m @ 100MHz**
- **lengths below 20m @ 31.25MHz**
- **lengths below 30m @ 30MHz**
- **lengths below 40m @ 10MHz**

Rule
- **Return loss is for information only**
- **NOT normative**



Configuration C Exclusion



No fails allowed at “x”
- **possible addition of cross-connect could jeopardize channel**

NEXT/PSNEXT may fail PL Limits at “y”
- **close proximity of CP and TO**
- **channel limits may be applied (proposal)**

Return loss may fail at “y”
- **close proximity of CP and TO**
- **channel limits may be applied (proposal)**
  - **provided that final channel also passes !!!!!!!**

Next Generation Copper

Session One

- Copper - Where are we now?
- Break
- Connecting Hardware
- Testing the Channels and Links
- **Next Generation Copper**
- Questions

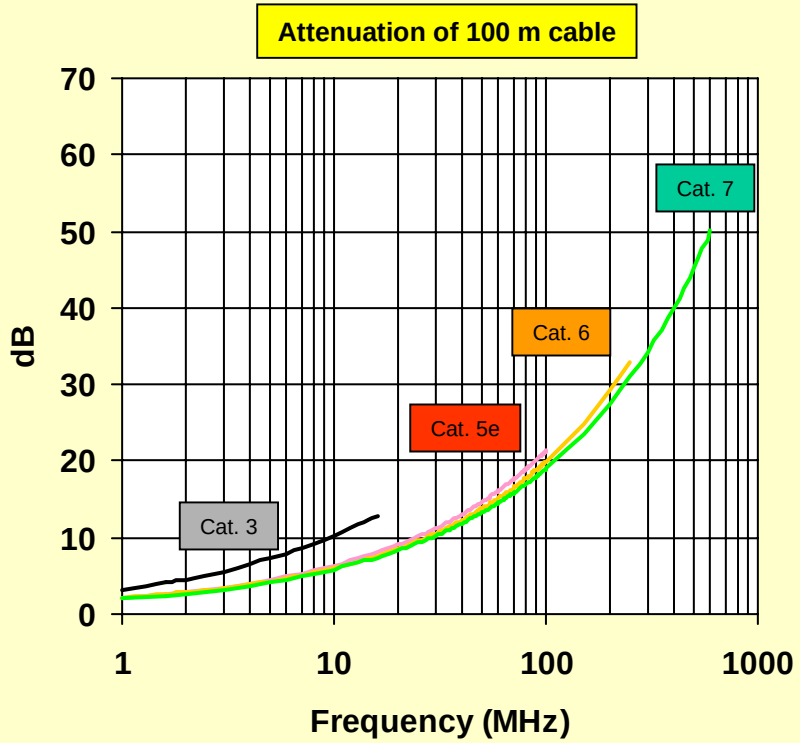
Session Two

- Optical Fibre - Selection Criteria
- 10 Gigabit Ethernet
- Break
- The Way Ahead
- The Impact of Stagnation
- Questions

Attenuation Profiles

Cable attenuation

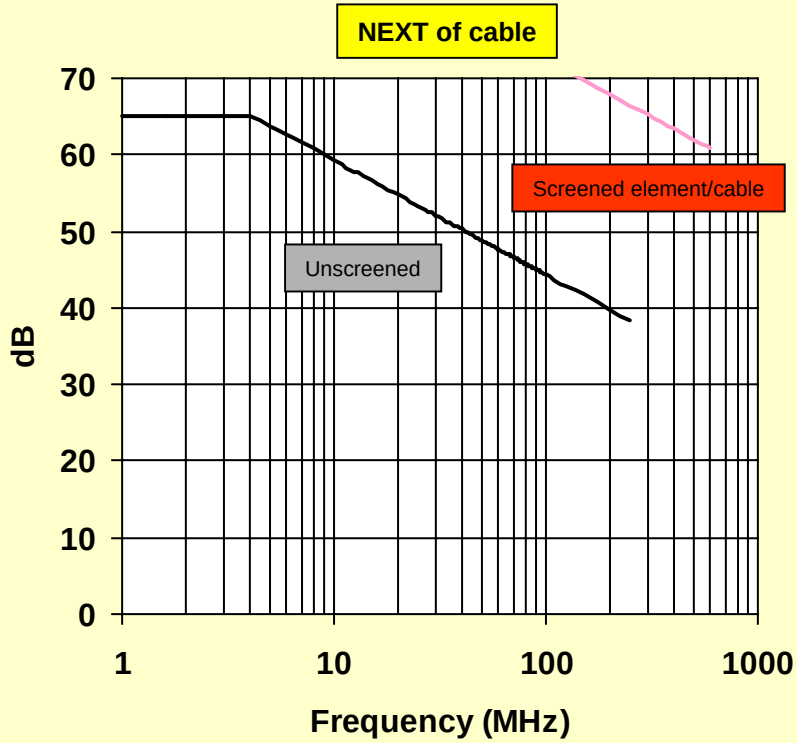
Reduction in attenuation
- **increased conductor diameter**
- **problems for the connector designer**



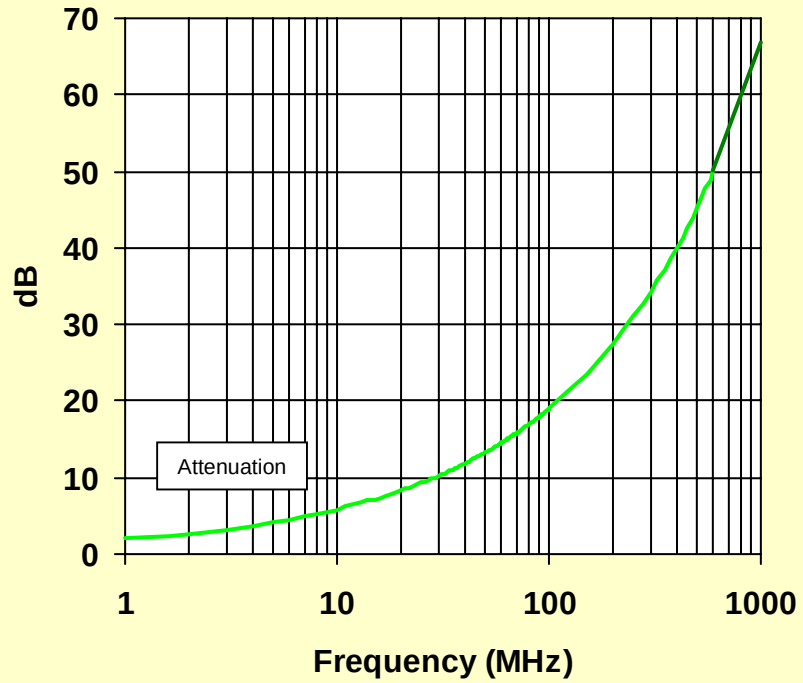
NEXT Profiles

Cable NEXT

Reduction in crosstalk
- **screened pair**
- **screened cable**



Increased Frequency Specification



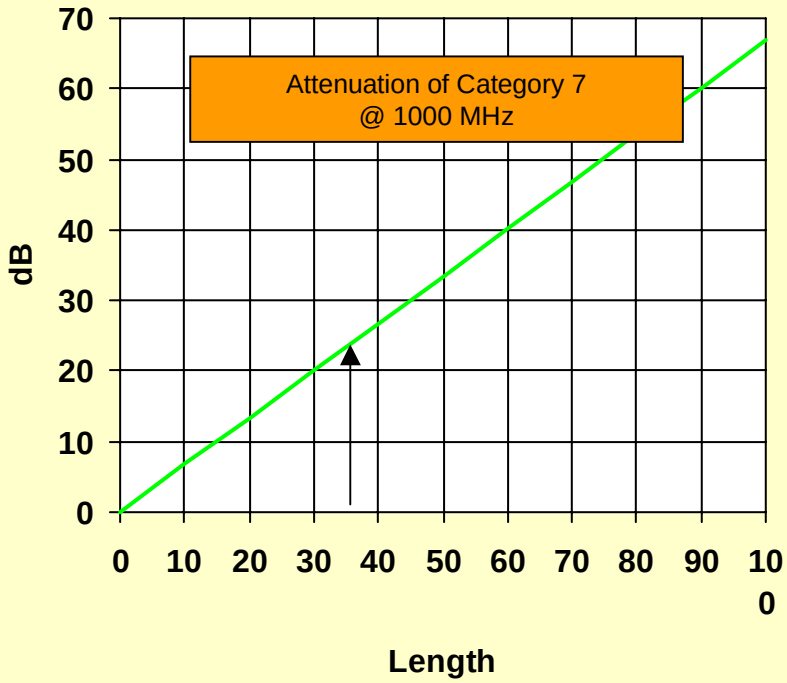
Next Generation Copper

Increased frequency - decreased distance

Attenuation 25 dB @ 1000 MHz = 20-30 m

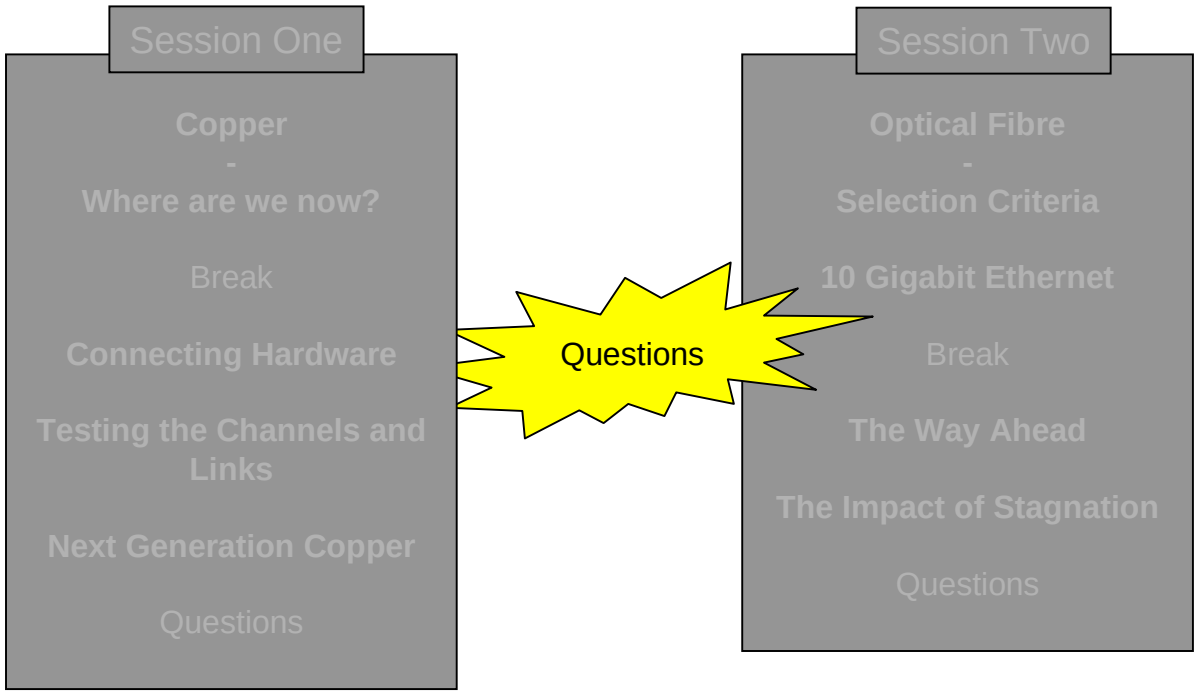
Proposals for “Category 8”

SOHO cabling for multimedia
ISO/IEC 15018
NOT a generic/structured cabling system

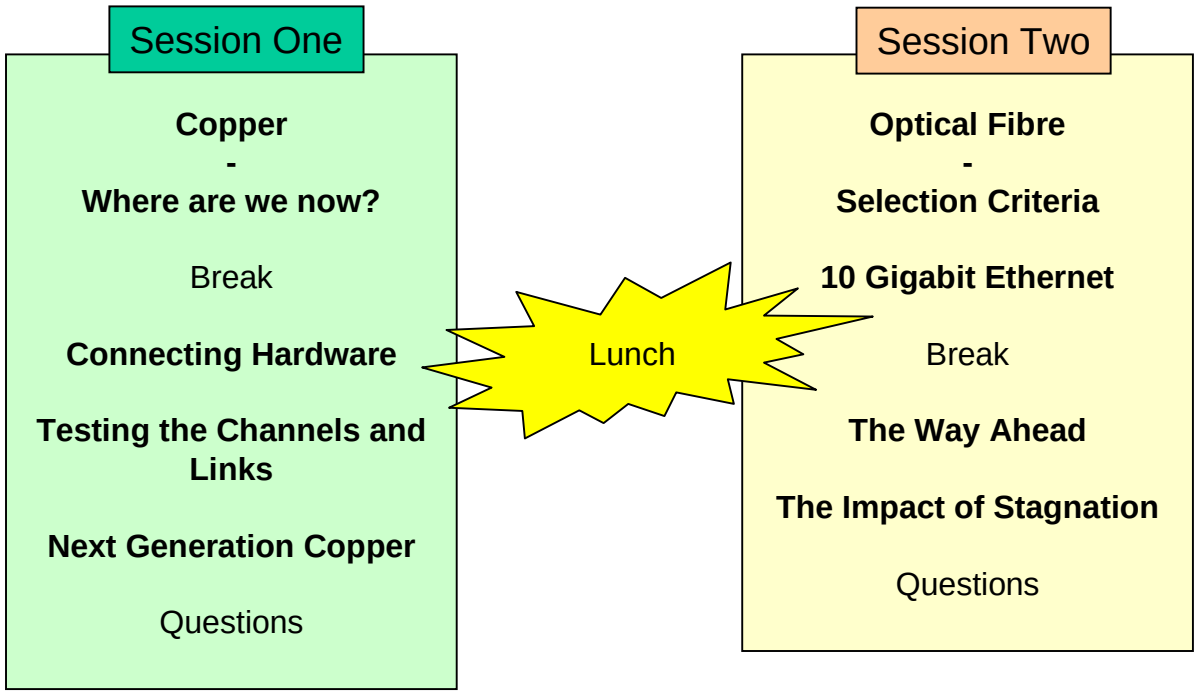


DATA CABLING IN THE MELTING POT - THE END IS NIGH

Agenda



Agenda



Optical fibre - Selection Criteria

Session One

Copper
-
Where are we now?

Break

Connecting Hardware

Testing the Channels and Links

Next Generation Copper

Questions

Session Two

Optical Fibre
-
Selection Criteria

10 Gigabit Ethernet

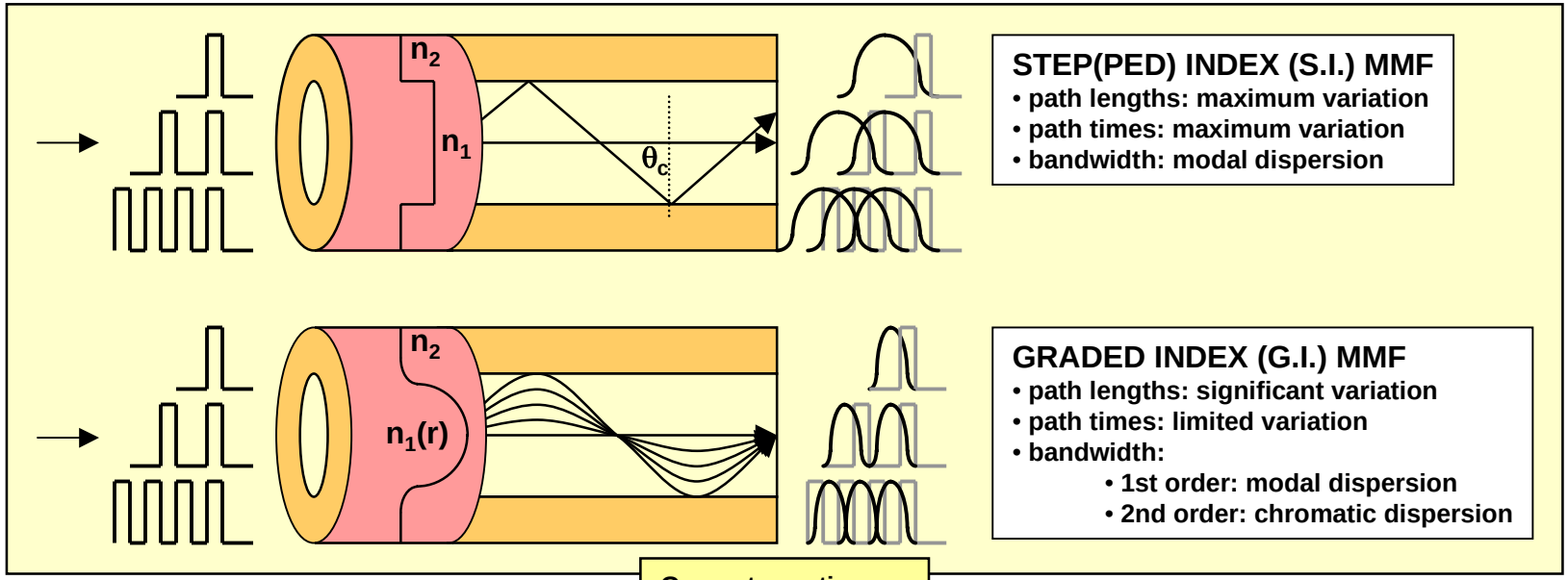
Break

The Way Ahead

The Impact of Stagnation

Questions

MMF: Multimode Optical Fibre



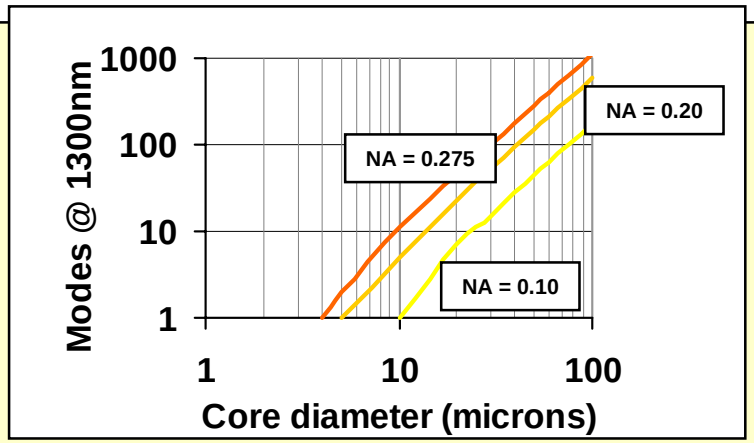
STEP(PED) INDEX (S.I.) MMF
- path lengths: maximum variation
- path times: maximum variation
- bandwidth: modal dispersion

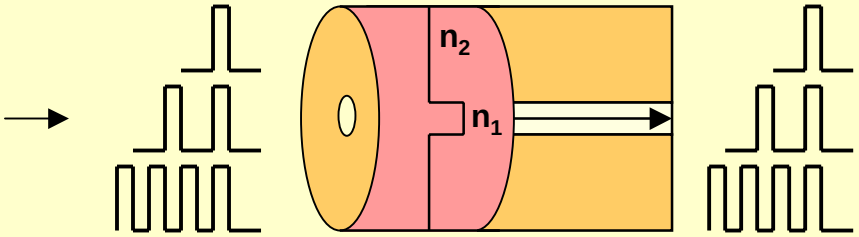
GRADED INDEX (G.I.) MMF
- path lengths: significant variation
- path times: limited variation
- bandwidth:
  - 1st order: modal dispersion
  - 2nd order: chromatic dispersion

Geometry options

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

SMF: Singlemode Optical Fibre



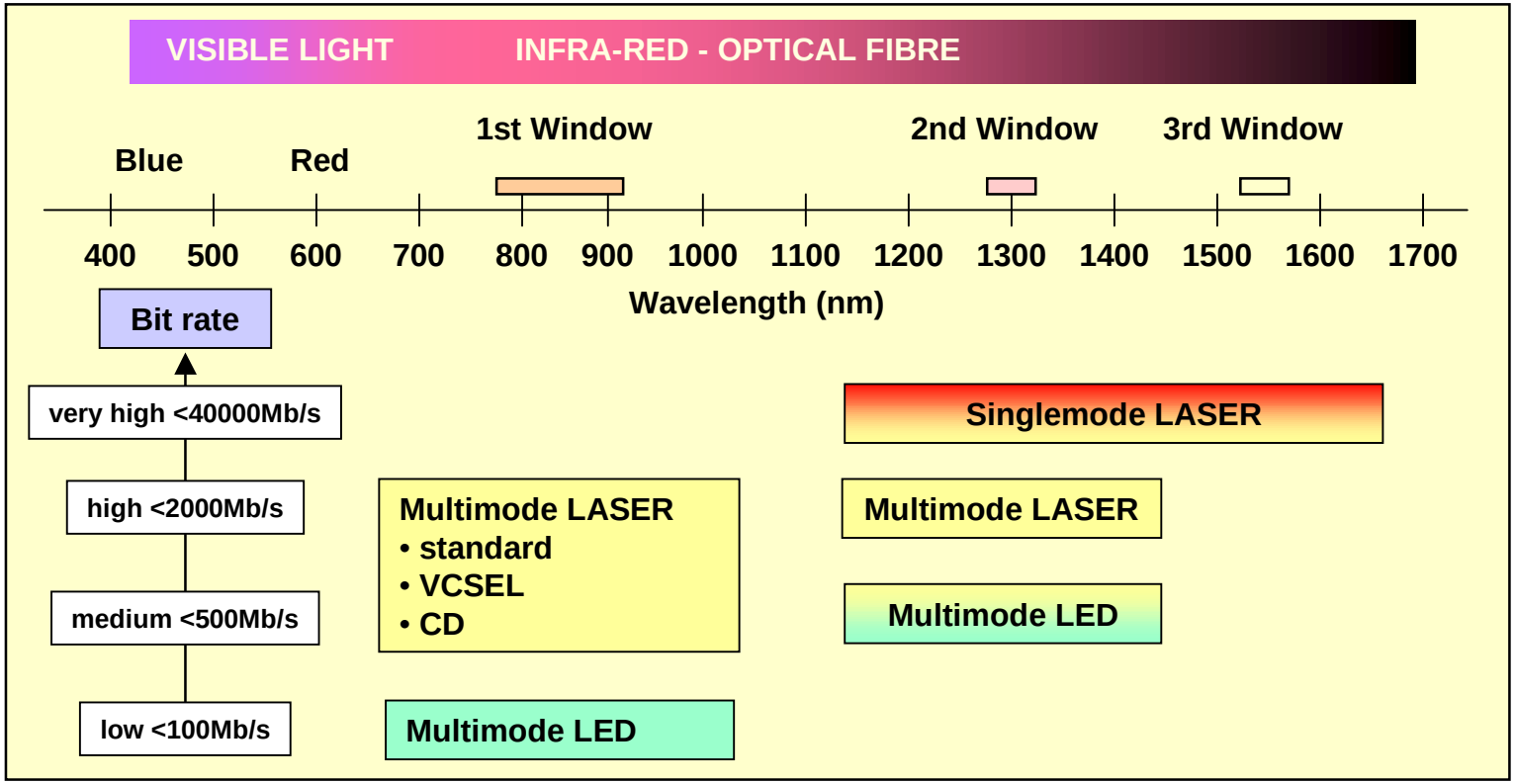


STEP(PED) INDEX (S.I.) SMF
- path lengths: no variation
- path times: no variation
- bandwidth:
  - 1st order: chromatic dispersion
  - 2nd order: pulse shape dispersion

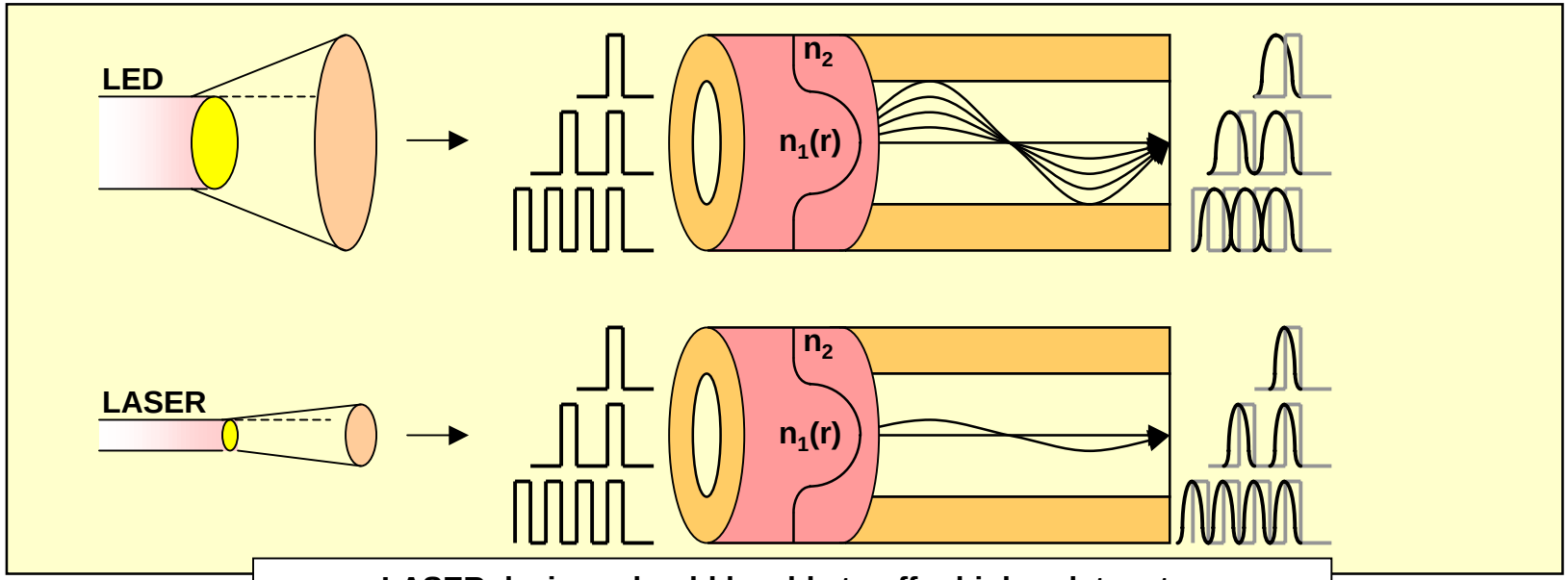
Geometry

d/D	NA
8-10/125	*0.10*

Injection Devices



MMF Bandwidth: LASER-LED



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

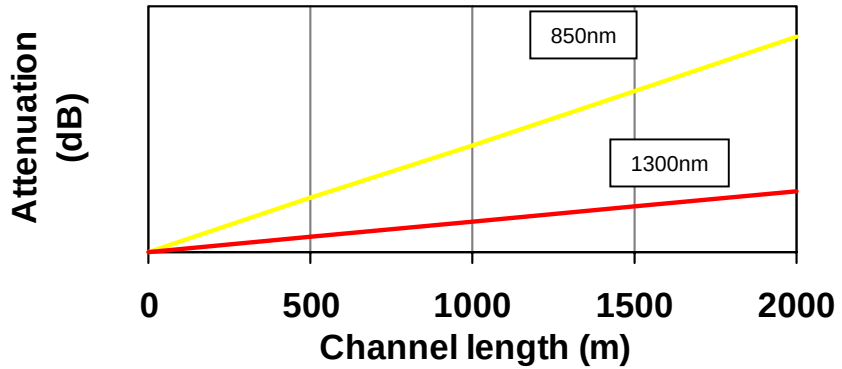
-

theoretically

MMF Specification - I

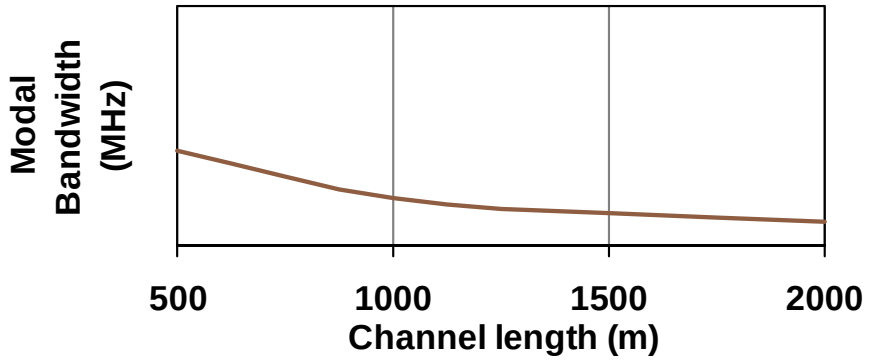
Optical fibre geometry (standardized)

	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)

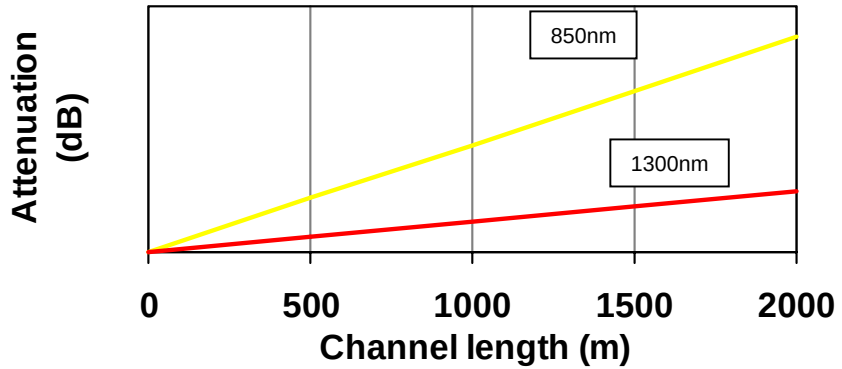
Attenuation coefficient dBkm^{-1} max.		Modal bandwidth MHz.km min.	
850nm	1300nm	850nm	1300nm
?	?	?	?



MMF Specification - II

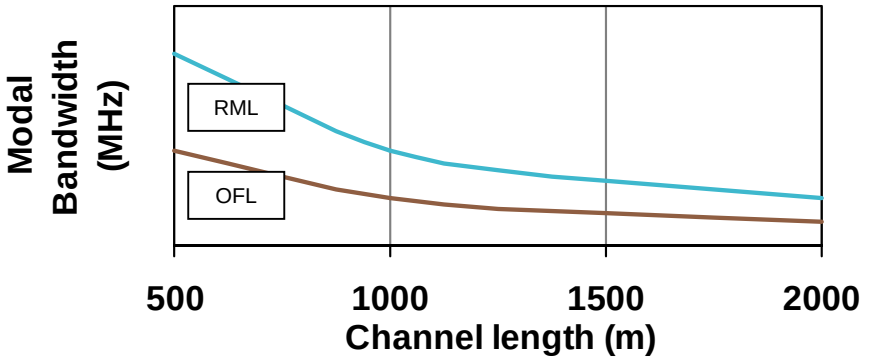
Optical fibre geometry (standardized)

	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	



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)

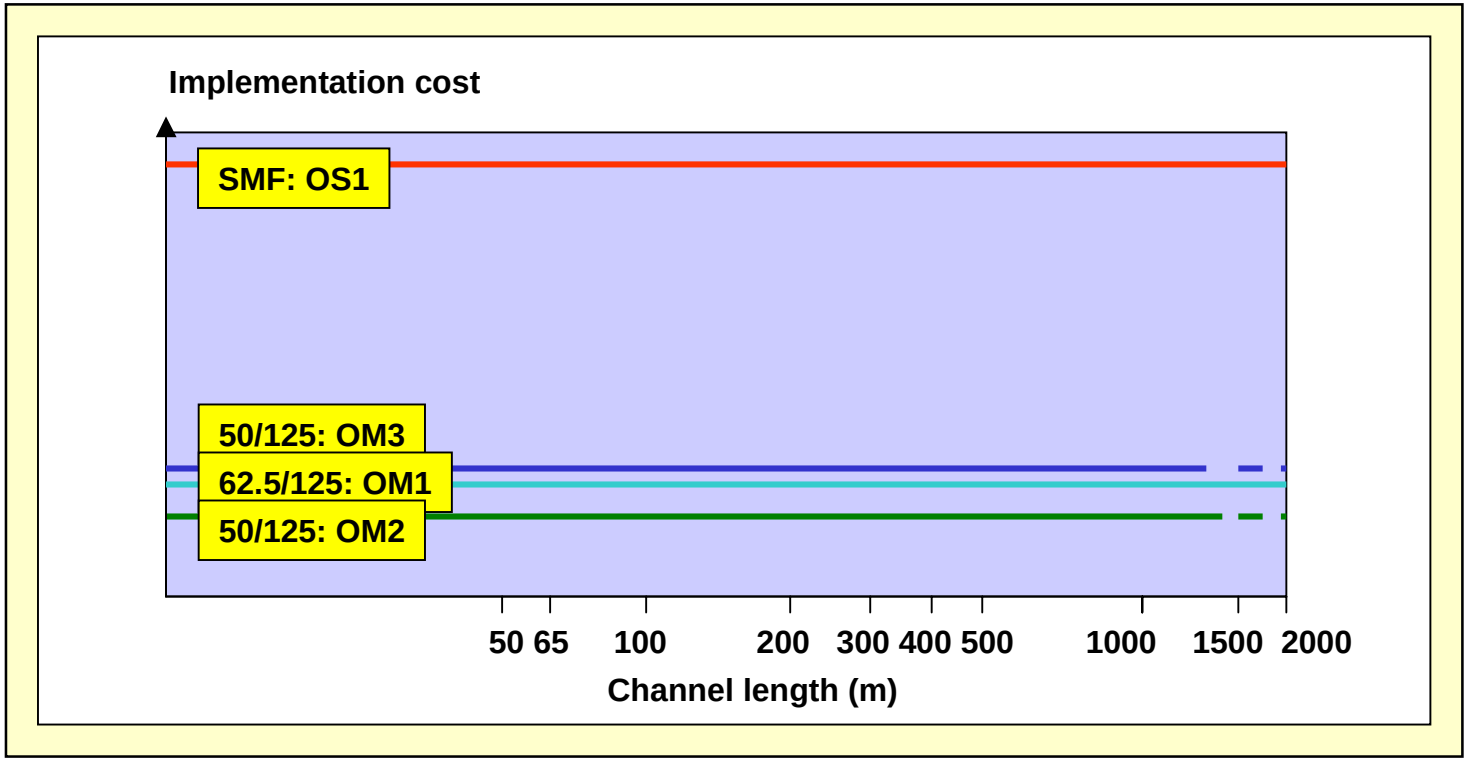
	Attenuation coefficient dBkm^{-1} max.			Modal bandwidth MHz.km min.				
	850nm	1300nm		850nm	1300nm	850nm	1300nm	
50/125	2.4 2.5 2.7	0.6 0.8 1.0	50/125	400 400 400 400 400 400 600	400 600 800 1000 1200 1500 1000	200 200	400 600	50/125 and 62.5/125
62.5/125	3.0 3.2	0.7 0.9				160 200 250 300	200 200 1000 800	62.5/125

MMF Categories - 2002

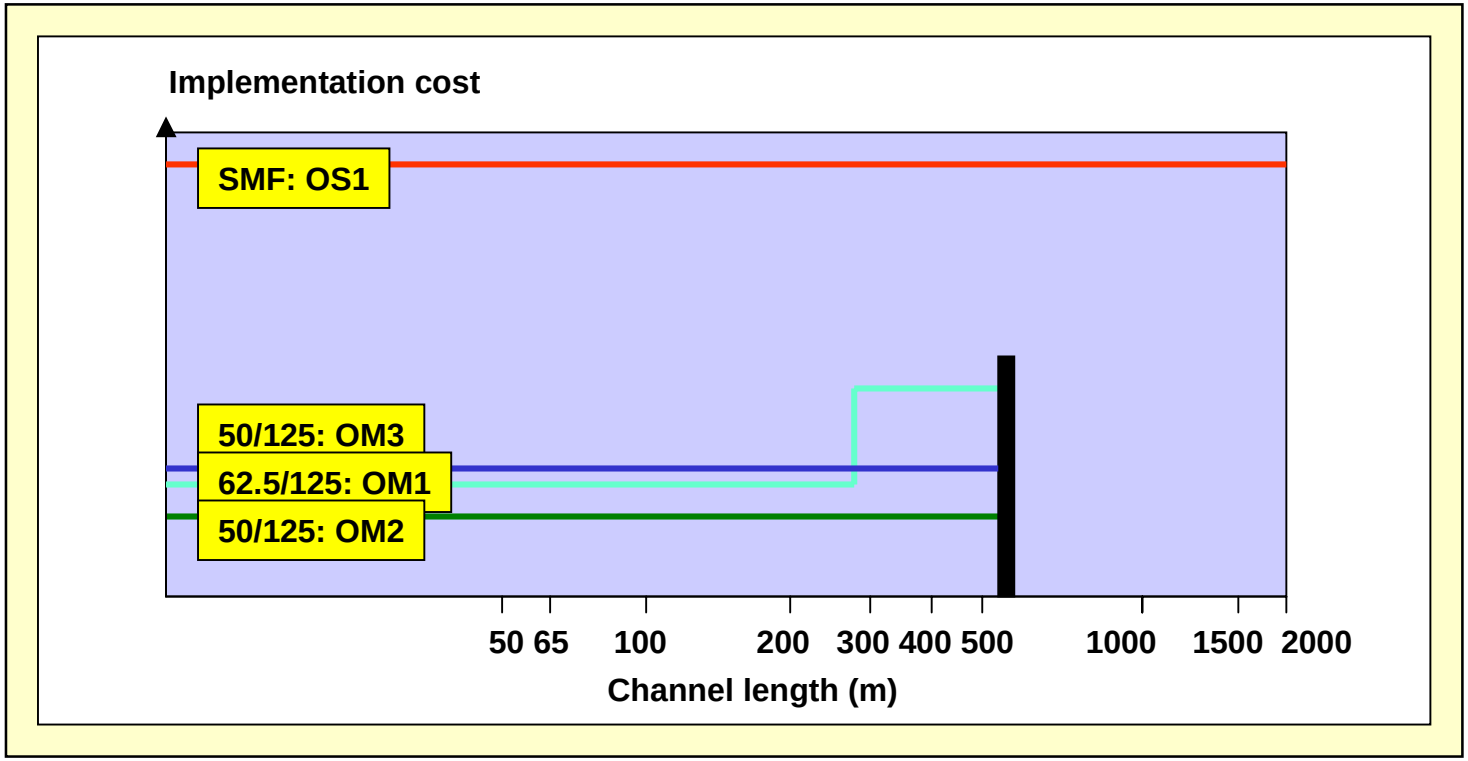
		50/125 or 62.5/125 Multimode OF		
	Wavelength	OM1	OM2	OM3
Attenuation coefficient (dBkm^{-1} max)	850 nm	3,5		
	1300 nm	1,5		
Modal bandwidth OFL (MHz.km min)	850 nm	200	500	500
	1300 nm	500	500	500
Modal bandwidth RML (MHz.km min)	850 nm	ffs	ffs	2000
	1300 nm	ffs	ffs	ffs
Propagation delay (ns.m^{-1}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

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

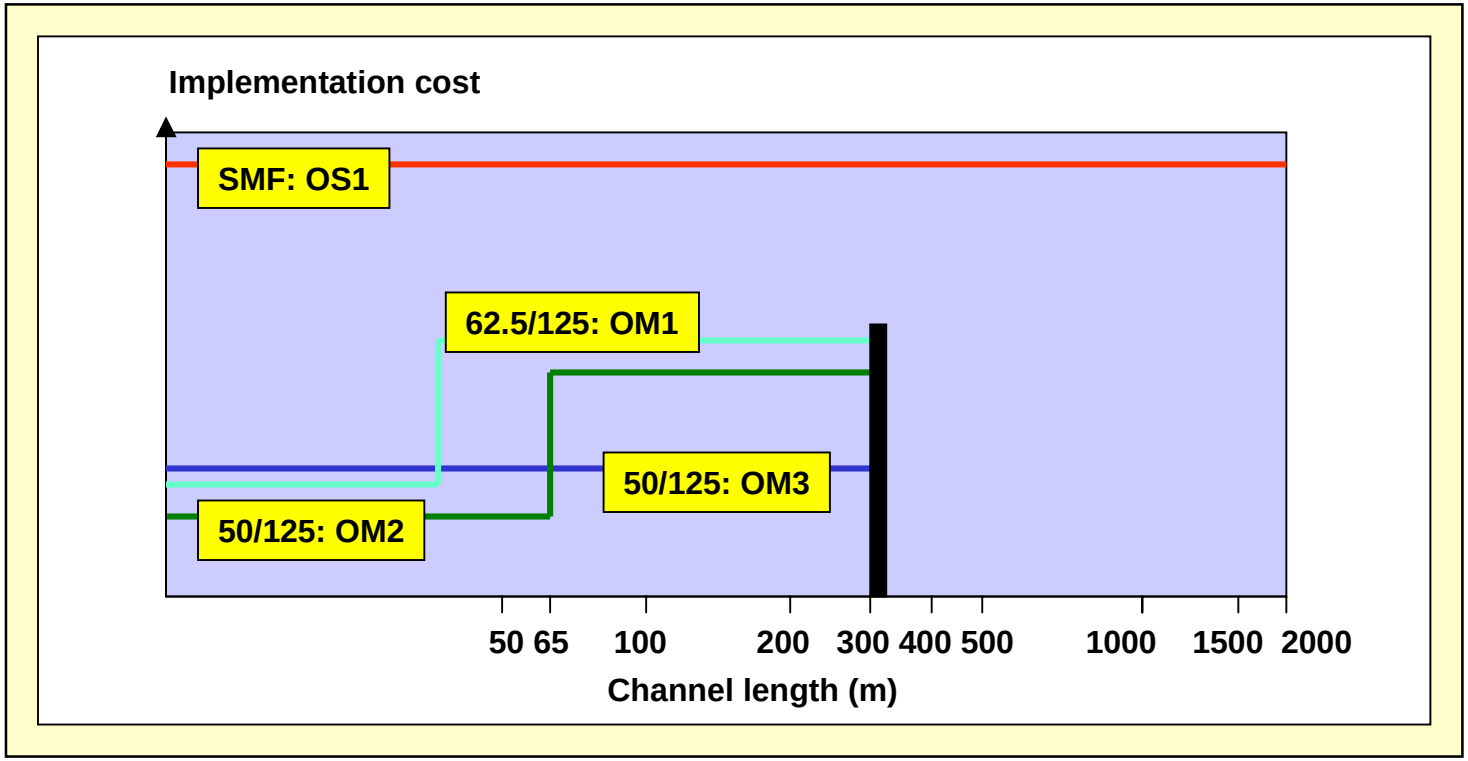
100Mb/s Implementation



1000Mb/s Implementation



10000Mb/s Implementation



Milestones for RL Modal Bandwidth

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

DATA CABLING IN THE MELTING POT - THE END IS NIGH

10 Gigabit Ethernet

Session One

- Copper
- Where are we now?
- Break
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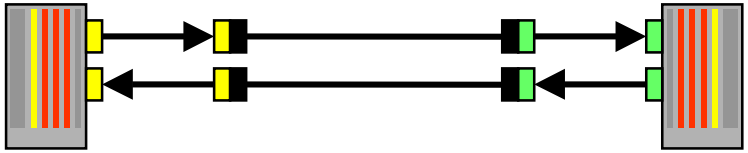
- Testing the Channels and Links
- Next Generation Copper
- Questions

Session Two

- Optical Fibre
- Selection Criteria
- **10 Gigabit Ethernet**
- Break
- The Way Ahead
- The Impact of Stagnation
- Questions

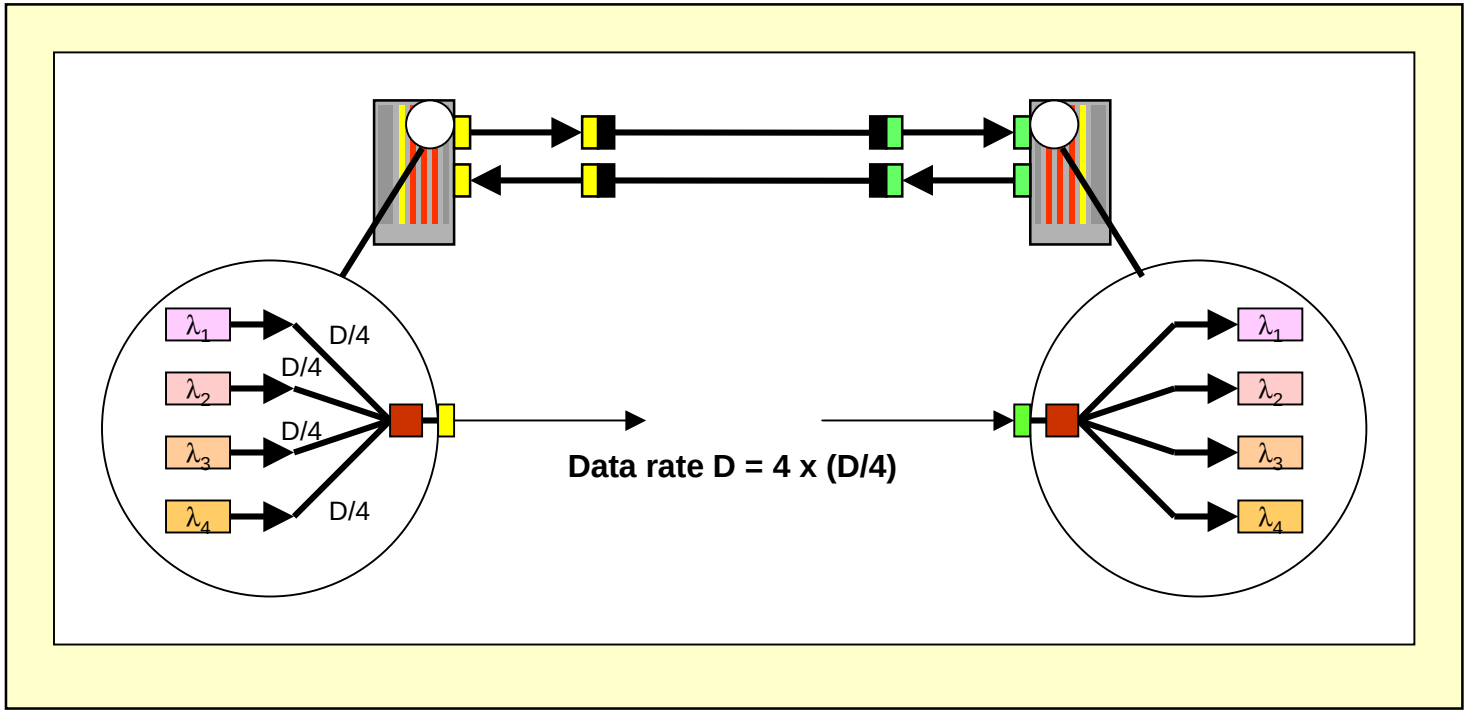
10 Gigabit Ethernet



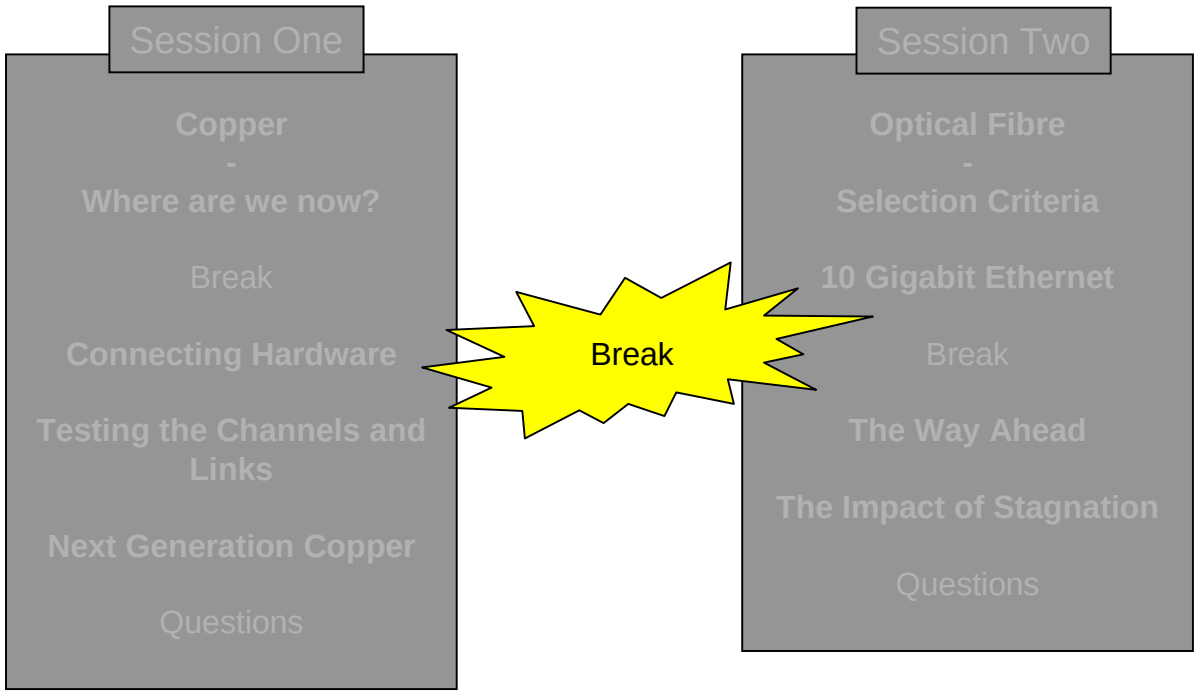
- switched operation only
- star topology
- support 10Gb/s Ethernet and 9.584640Gb/s SONET
- 2000 m, 10000 m and 40000 m over SMF
- 100 m over existing MMF

	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	LAN
Legacy support	< 300 m	MMF	1300	OMx	WWDM	
	< 10000 m	SMF	1310	OS1	Serial	
	< 40000 m	SMF	1550	OS1	Serial	M/WAN

WWDM



Agenda



The Way Ahead

Session One

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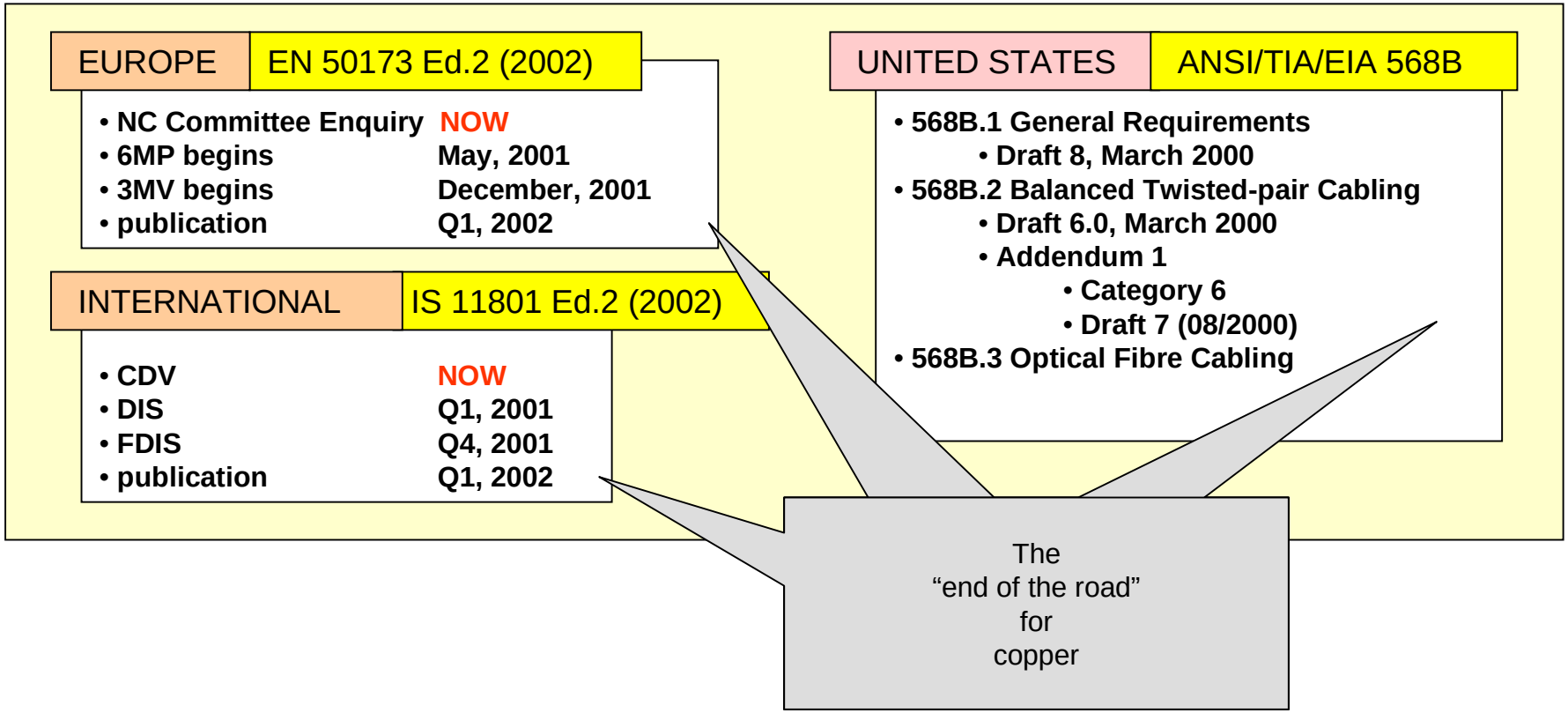
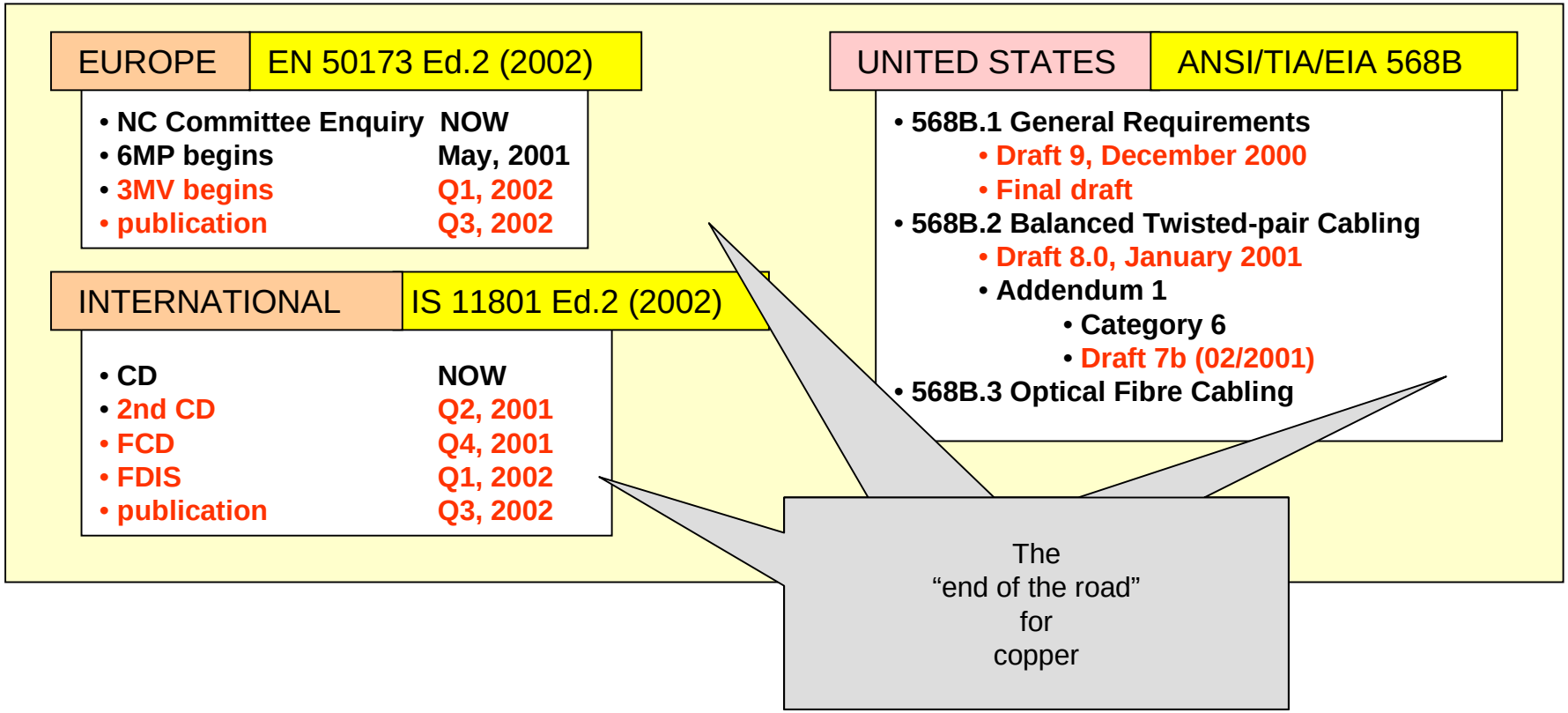
Standards Development - 01/01



Standards Development - 03/01



The Impact of Stagnation

Session One

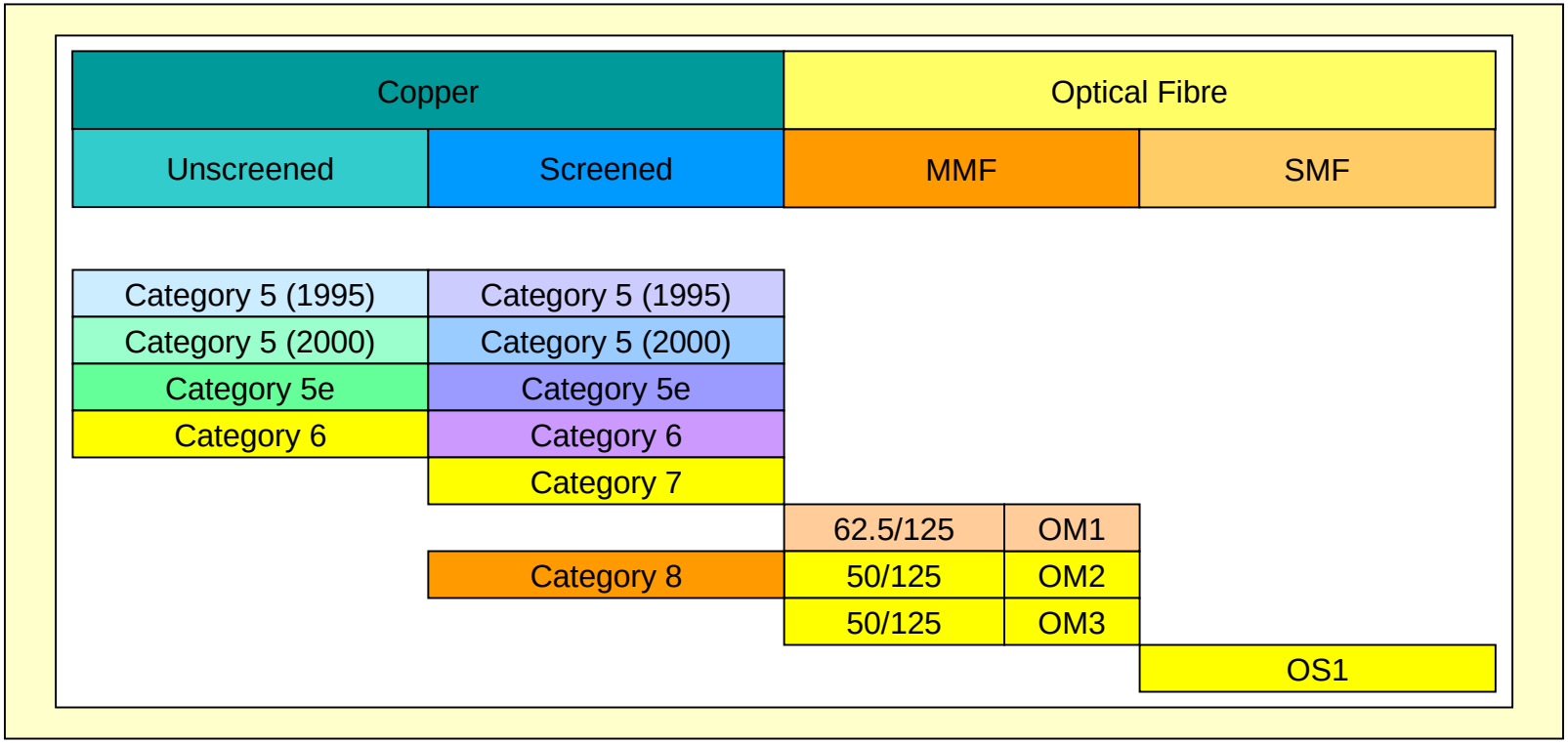
- **Copper - Where are we now?**
- Break
- **Connecting Hardware**
- **Testing the Channels and Links**
- **Next Generation Copper**
- Questions

Session Two

- **Optical Fibre - Selection Criteria**
- **10 Gigabit Ethernet**
- Break
- **The Way Ahead**
- **The Impact of Stagnation**
- Questions

DATA CABLING IN THE MELTING POT - THE END IS NIGH

The Technology Squeeze



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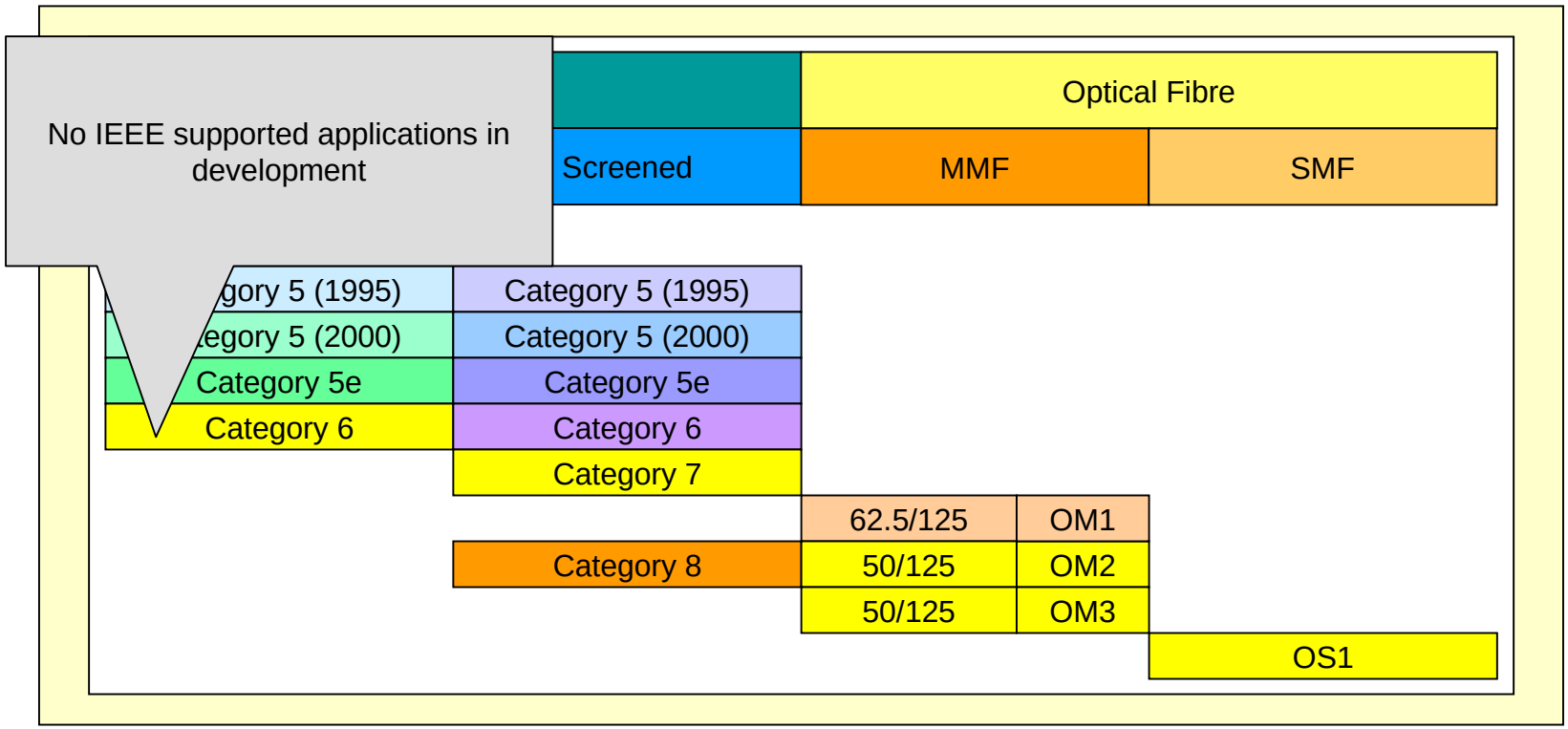

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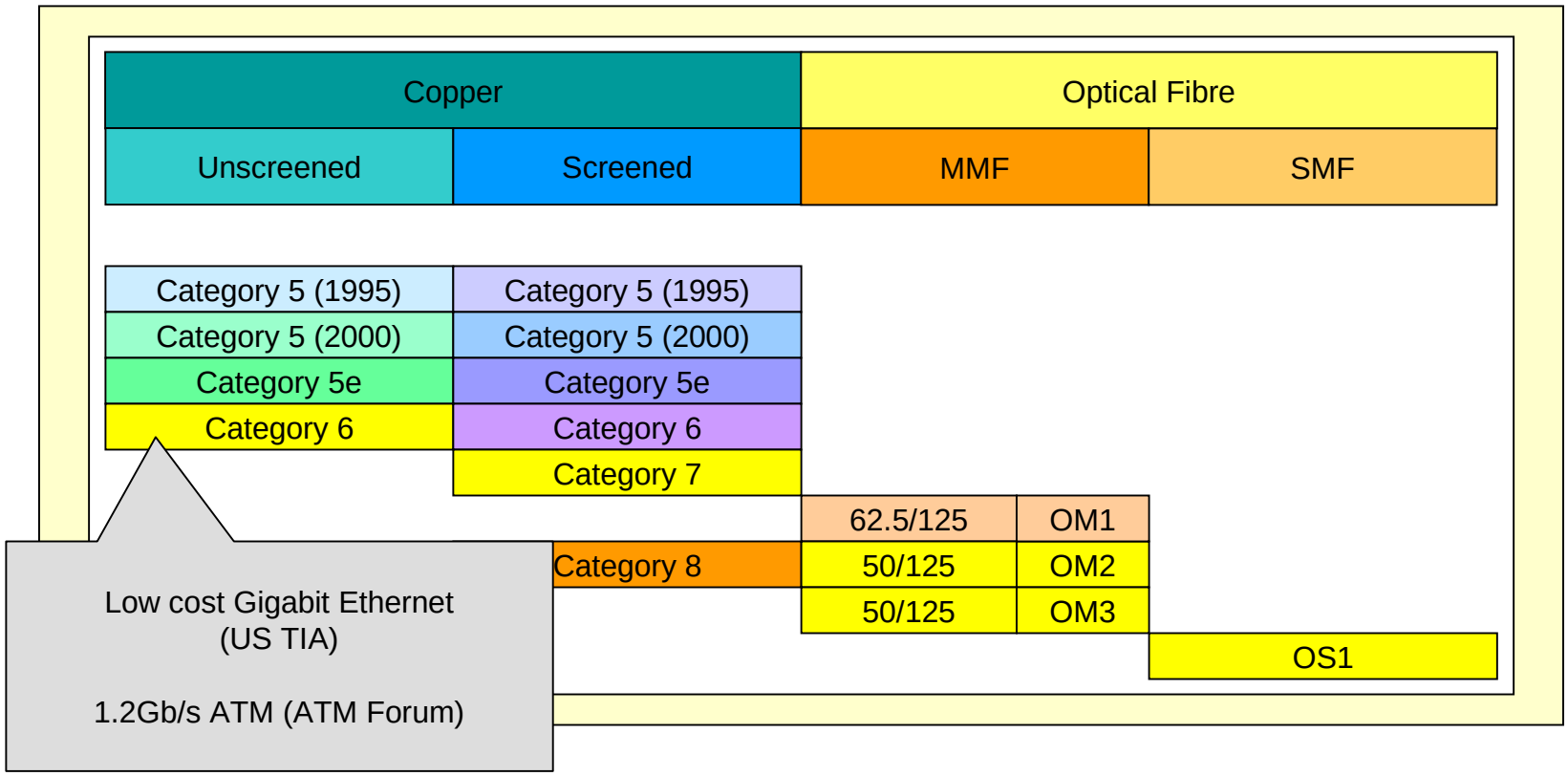
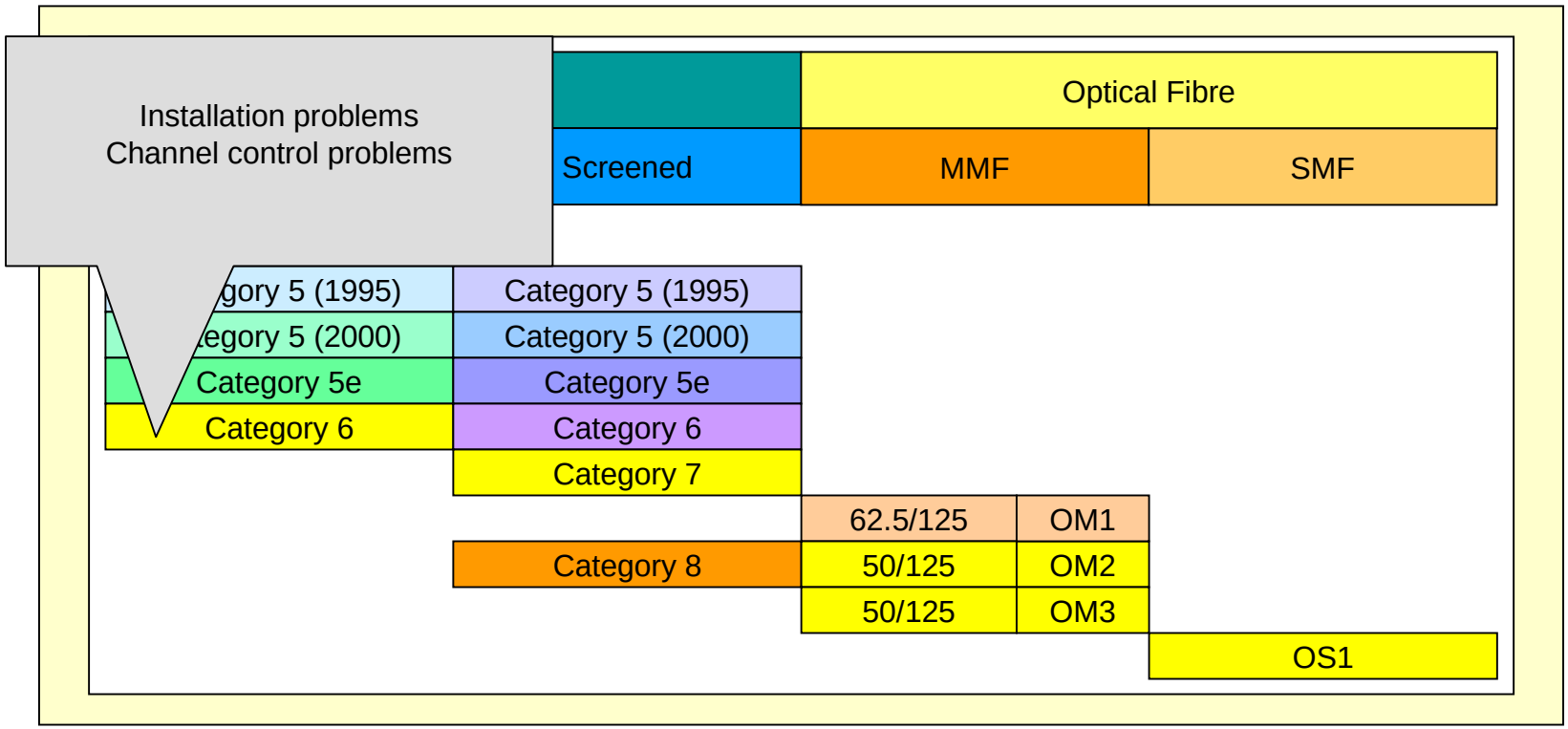


The Technology Squeeze



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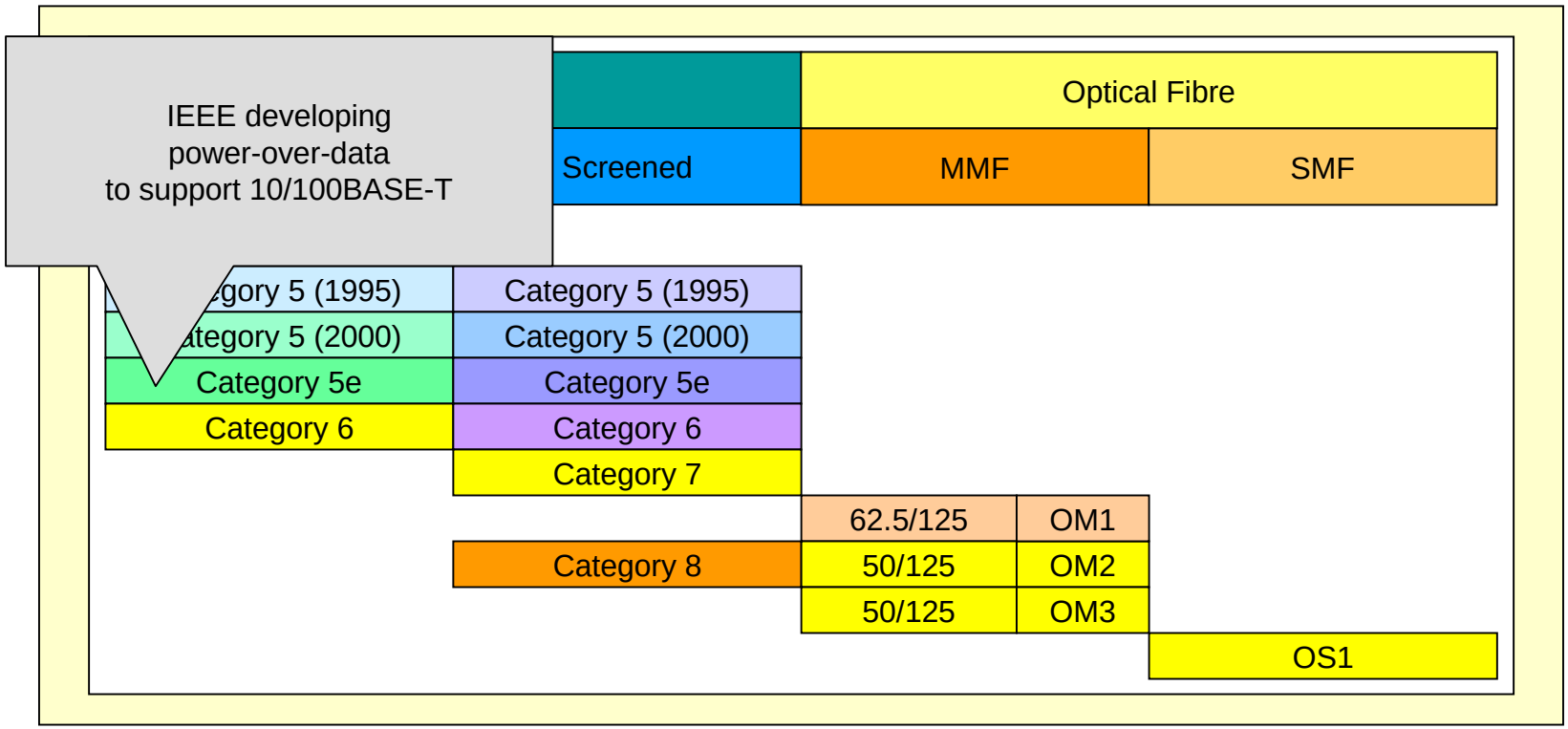

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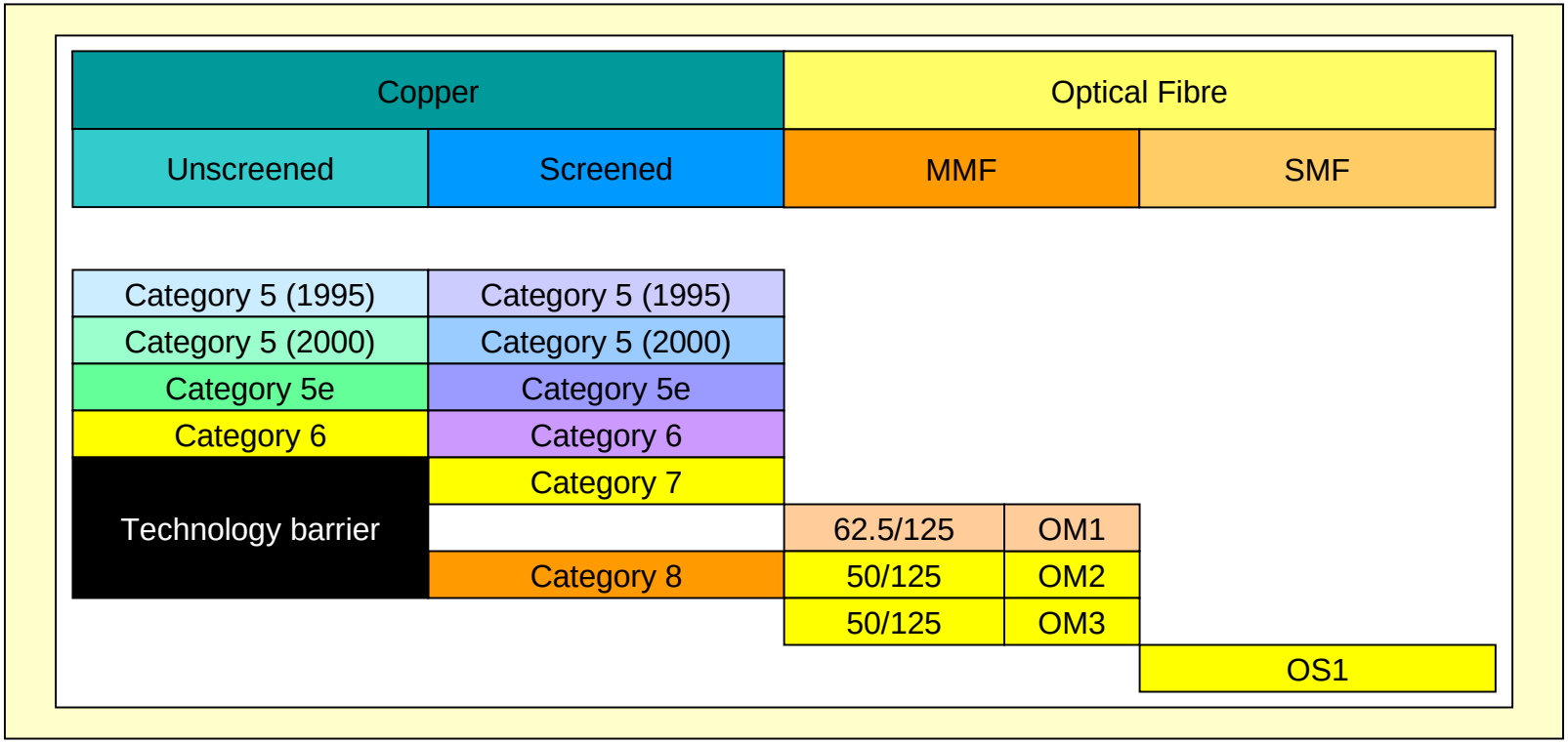

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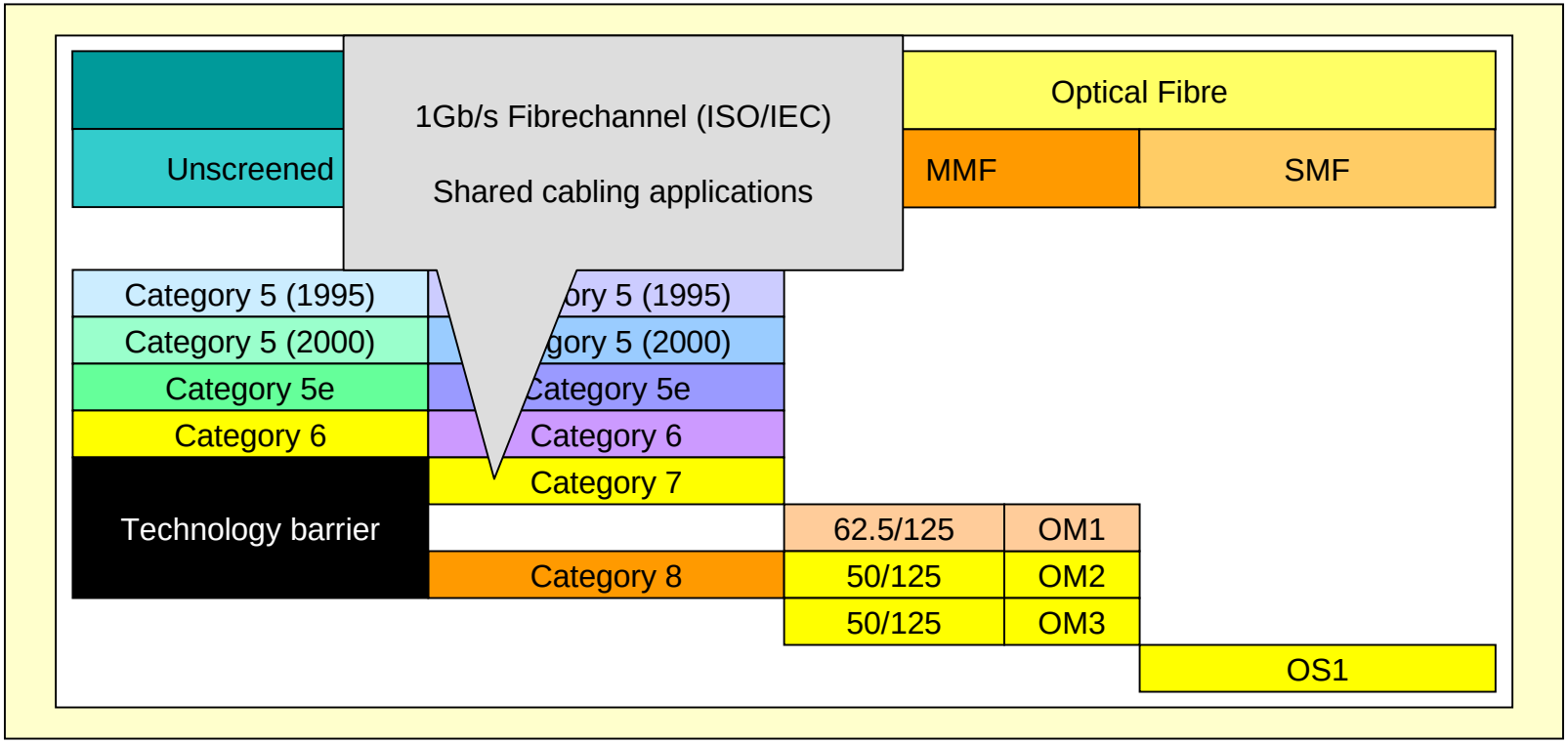

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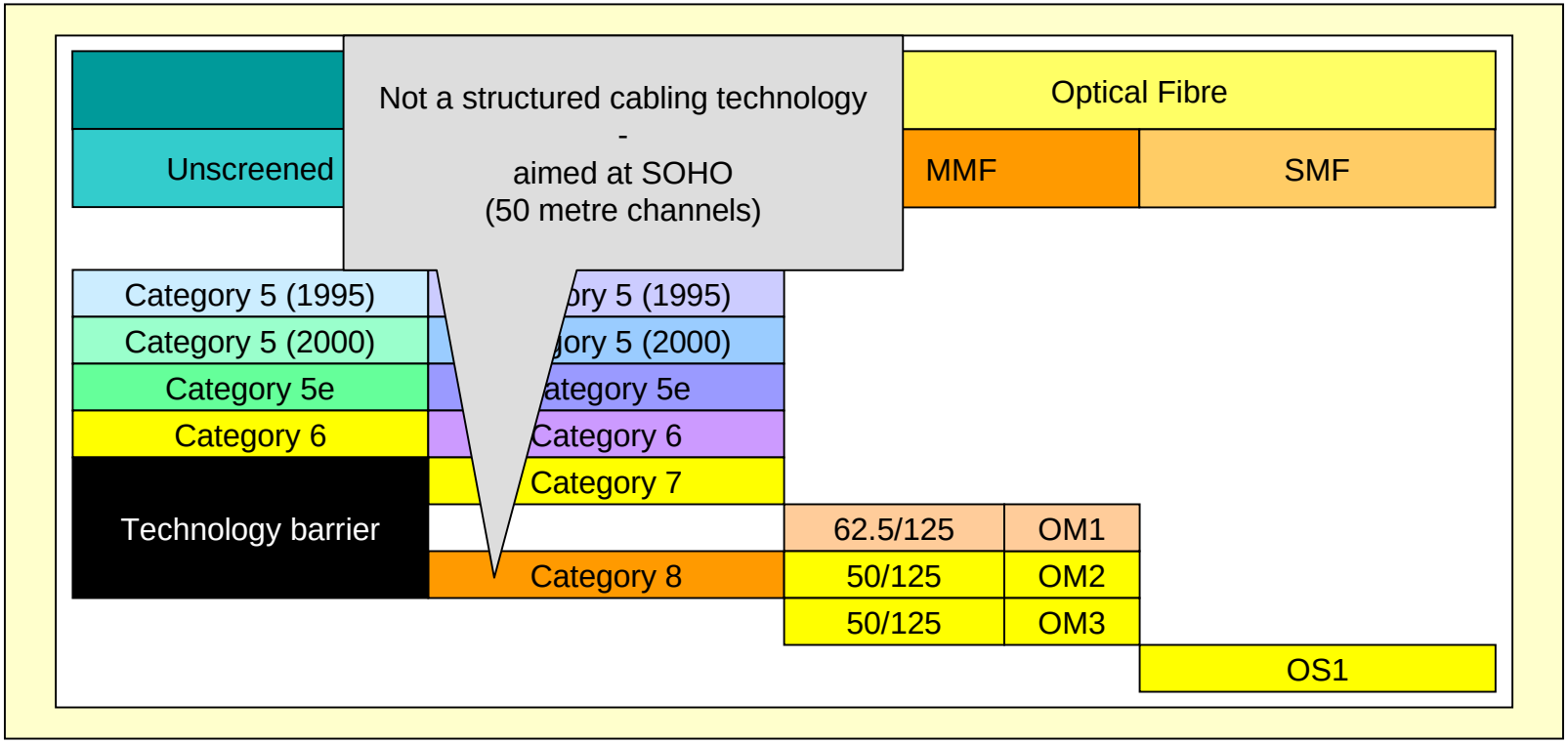

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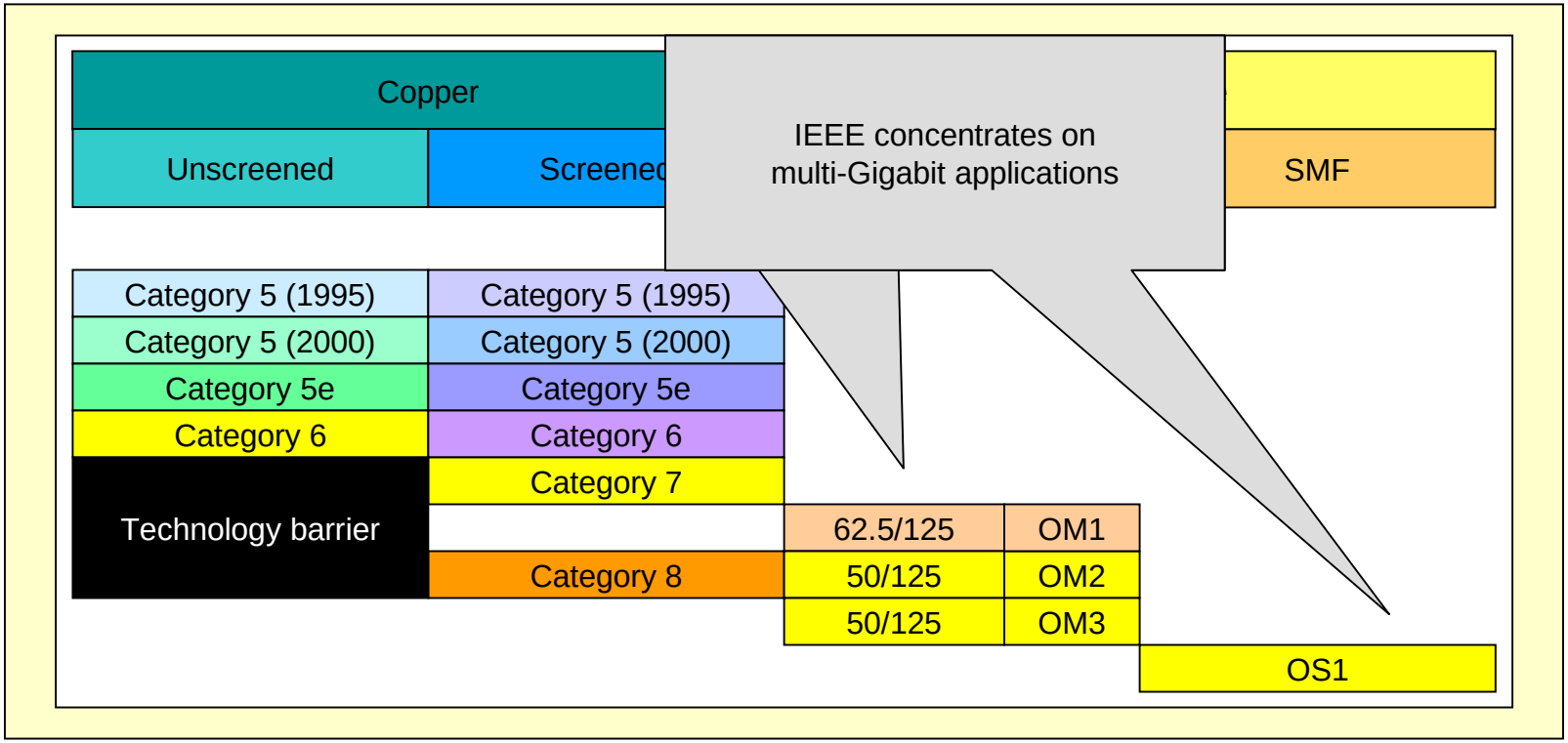
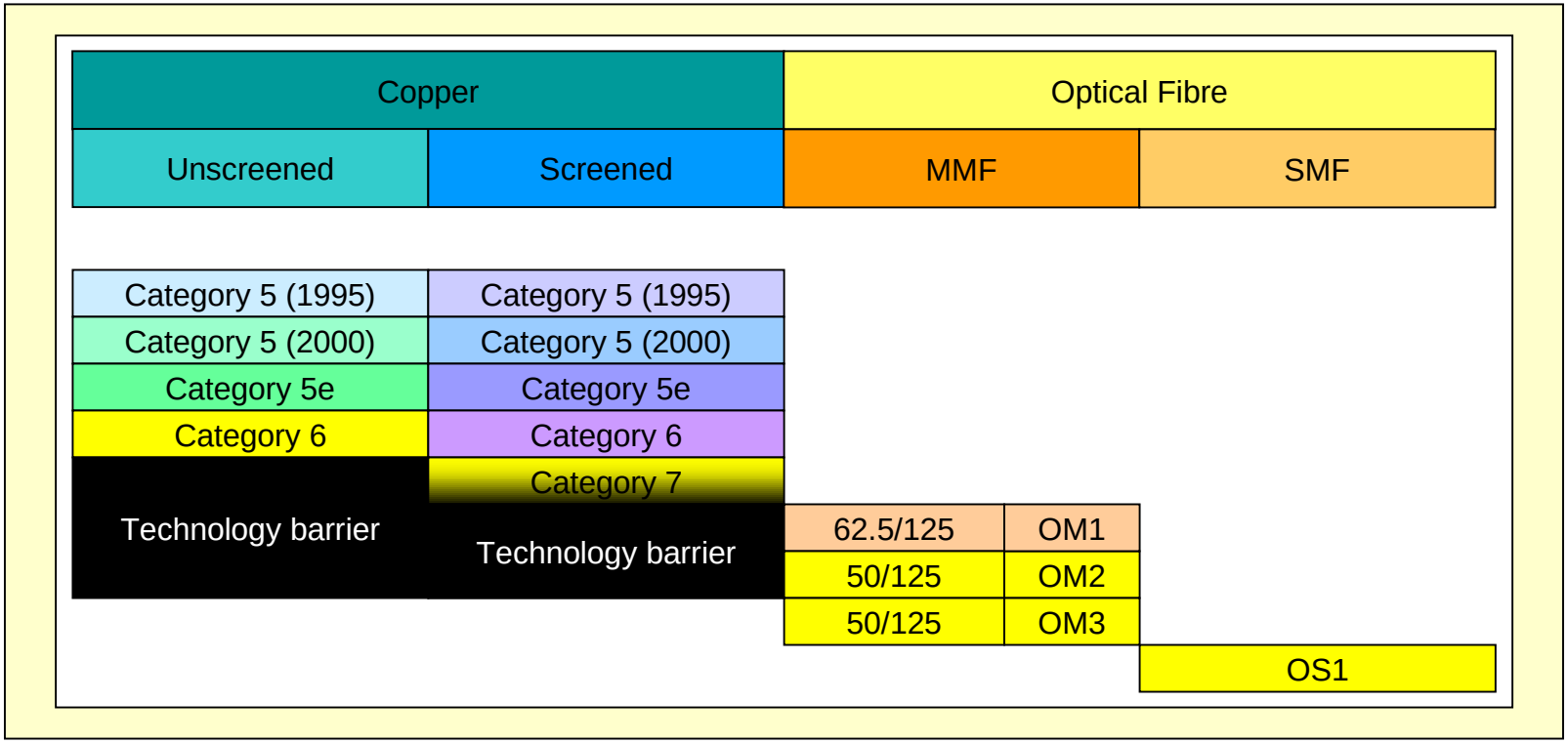


DATA CABLING IN THE MELTING POT - THE END IS NIGH

The Technology Squeeze



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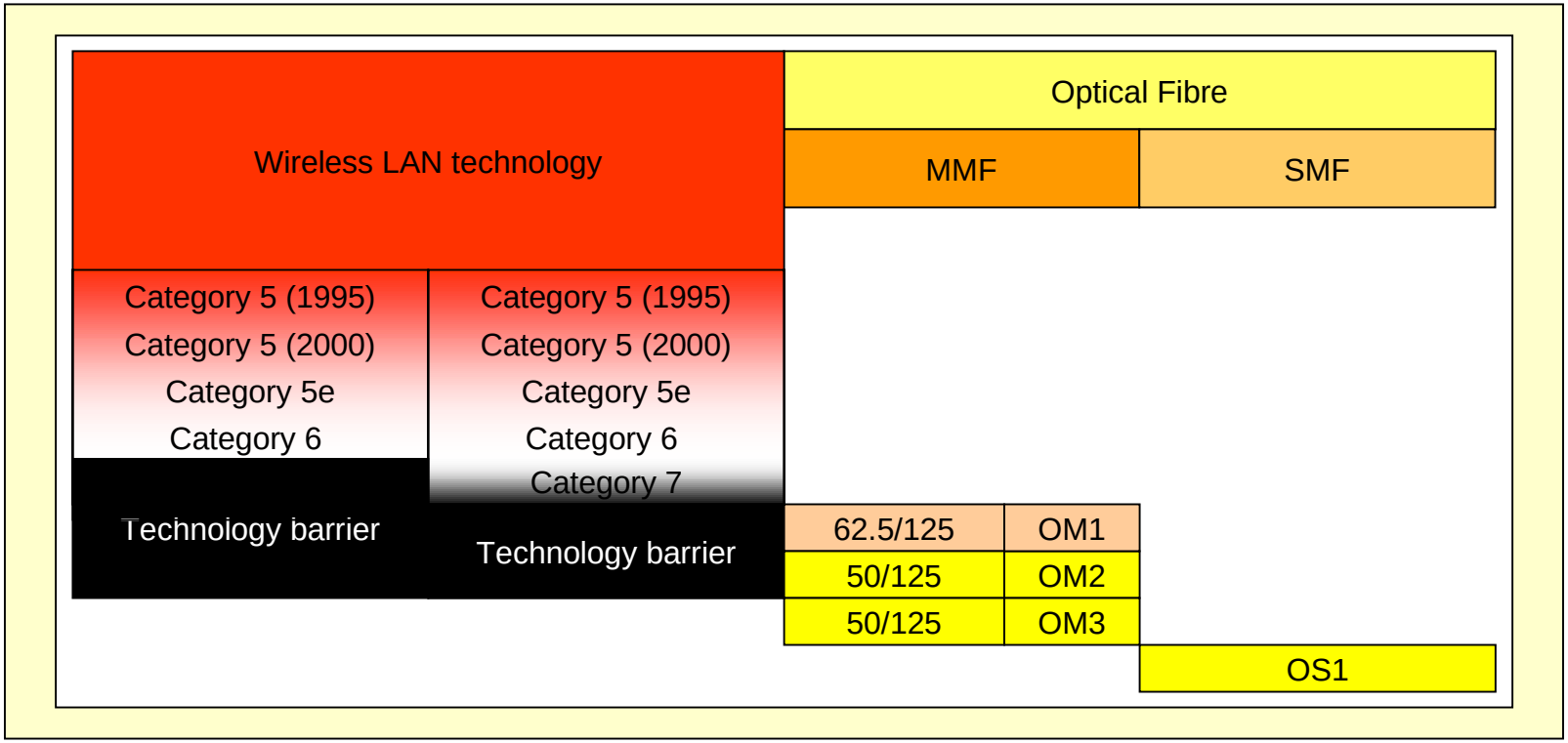
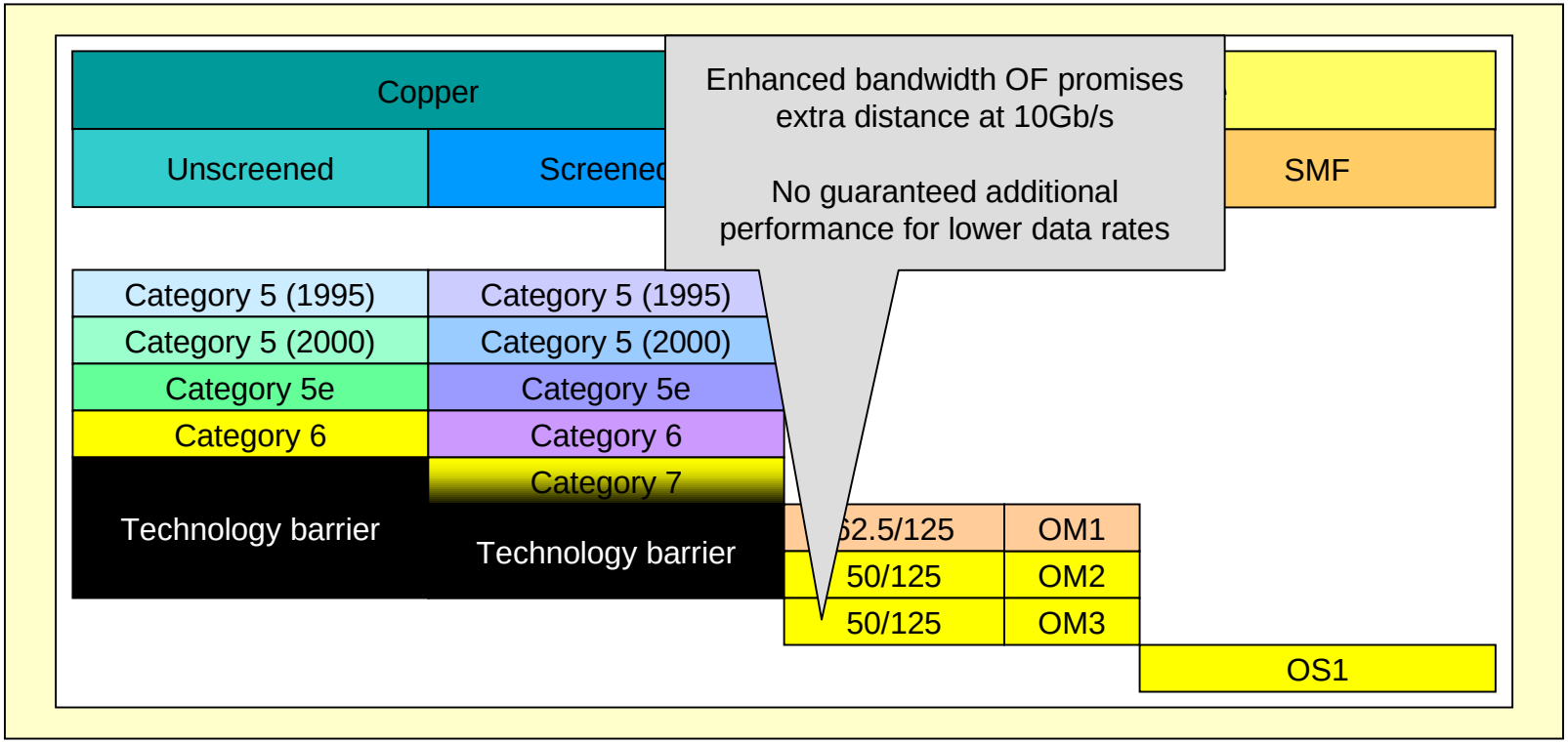


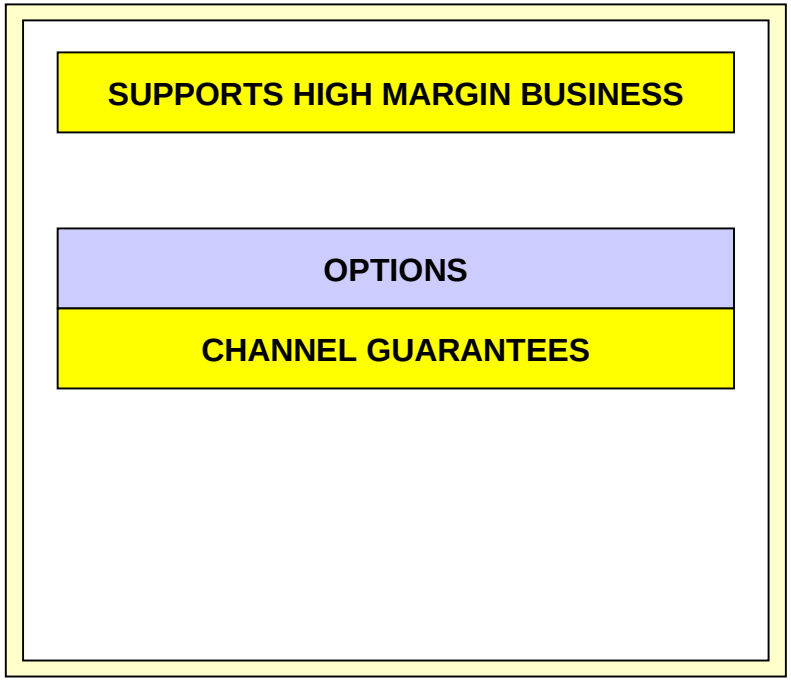
The Technology Squeeze



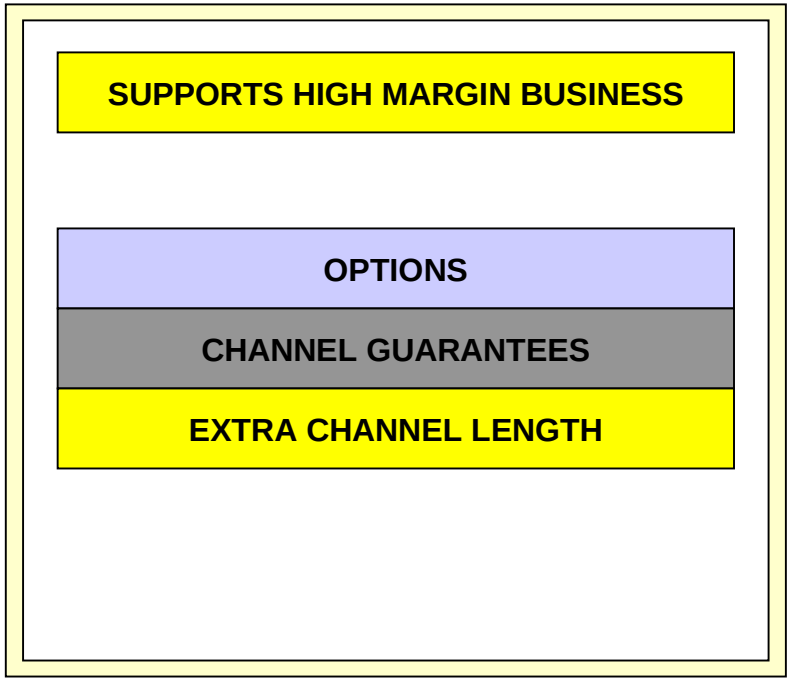
Product Differentiation

SUPPORTS HIGH MARGIN BUSINESS

Product Differentiation



Product Differentiation



Product Differentiation

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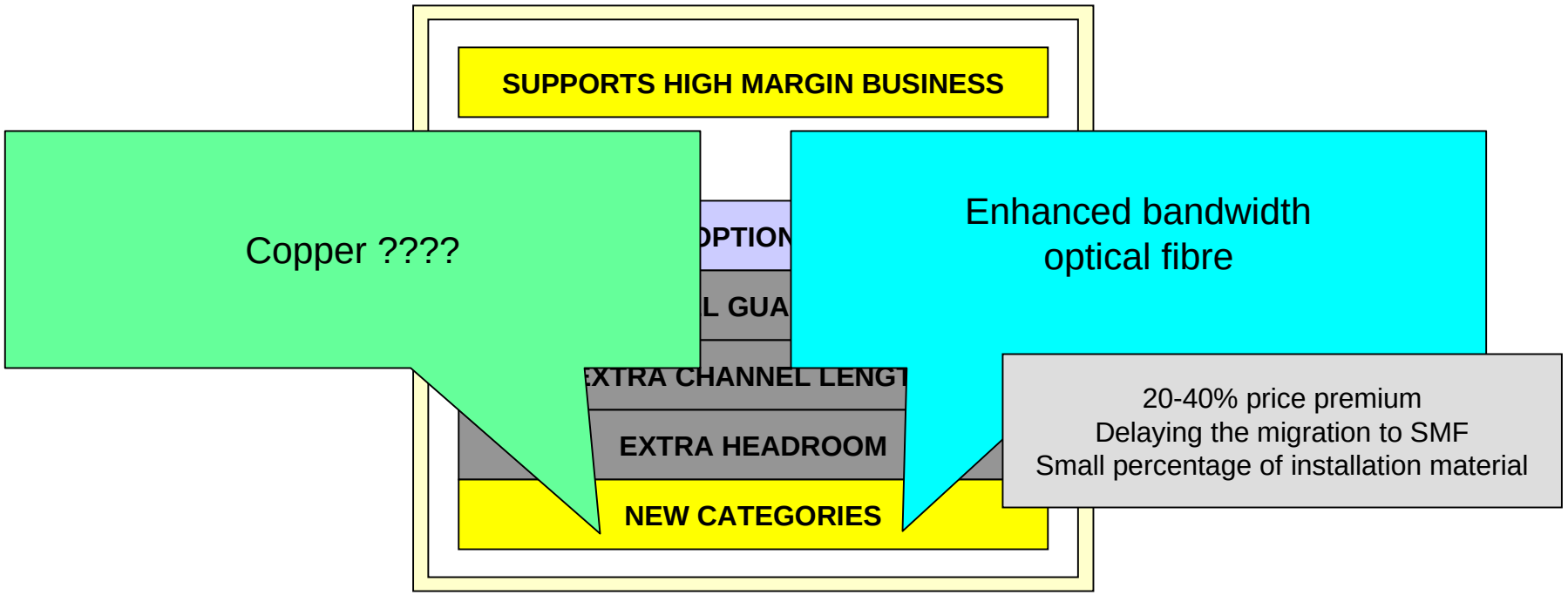
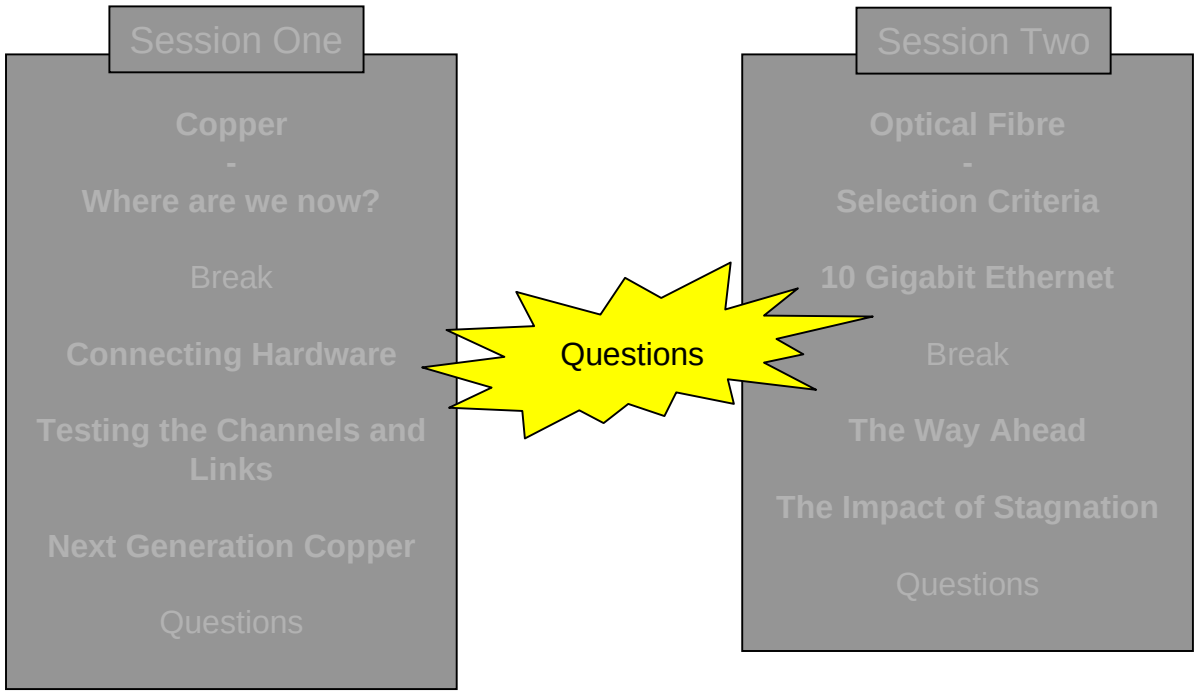


Agenda



The End

- full colour copy of presentation
  - www.it-cabling.com/gendocs/tein.pdf