

From 10G to 400G: Analysis of the Past, Current and Future Infrastructure solutions

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Agenda

1- Copper Systems

2- Fiber Systems





**IEEE 802:
LAN / Man Standards**

*802.5: Token Ring
(disbanded)*

**802.1: Higher LAN
Protocols**

**802.15: WPAN
(bluetooth,
Zigbee,...)**

IEEE 802: LAN / MAN standards

802.3 Ethernet (CSMA / CD)	802.11 Wireless (CSMA / CA)
802.3j (1990) 10base-T, 10base-F	802.11a (1999) 54Mbps @ 5GHz
802.3u (1995) 100base-TX, 100base-T4, 100base-FX	802.11b (1999) 11Mbps @ 2.4GHz
802.3z (1998) 1000base-X (Fiber optic)	802.11g (2003) 54Mbps @ 2.4GHz
802.3ab (1999) 1000base-T	802.11n (2012) 150Mbps @ 2.4 and 5GHz, 600M w/MIMO 4
802.3ae (2003) 10G on fiber	802.11ac (2012) 867Mbps @ 5GHz , 6.77G w/ MIMO 8
802.3af (2003) Power over Ethernet, 15w	802.11ad (2013) 6.75Gbps @ 2.4, 5, and 60GHz
802.3an (2006) 10Gbase-T	802.11ax (2019?) improvement of 802.11ac for high density
802.3at "PoE+" 30W	
802.3ba (2010) 40G and 100G on fiber	
802.3bq (2016) 25Gbase-t and 40Gbase-T	
802.3bz (2016) 2.5Gbase-t and 5Gbase-T	
802.3bs (2018) 200G and 400G on fiber	
802.3bt (2018 ?) "PoE++" 100W	



ISO, International



Components



ISO Information Technology Generic Cabling Systems

Performance, Design

ISO/IEC 11801-1 (2017)
General requirements

ISO/IEC 11801-2 (2017)
Offices and commercial buildings

ISO/IEC 11801-3 (2017)
Industrial premises

ISO/IEC 11801-4 (2017)
Homes

ISO/IEC 11801-5 (2017)
Data centers

ISO/IEC 11801-6 (2017)
Distributed building services

ISO/IEC TR 24750 (2007)
Assessment and mitigation of installed balanced cabling channels in order to support of 10GBASE-T

ISO/IEC TR 24704 (2004)
Cabling for wireless access points

ISO/IEC TS 29125 (2017)
Requirements for remote powering of terminal equipment

Implementation

ISO/IEC 14763-2
Planning and Installation Implementation

Validation

ISO/IEC 61935-1
Testing of balanced twisted Pair Cabling

ISO/IEC 14763-3
Testing of Fiber Optic Cabling



TIA, North American



ANSI/TIA: Telecommunications Cabling for Customer Premises

Components, Performance	Design	Implementation	Validation
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TIA - 568.2-D Balanced twisted-pair cabling	TIA - 568.0-D Generic cabling	TIA - 569-D Telecommunications pathways and spaces	TIA - 526-7-A Single-mode fibre testing
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TIA - 568.3-D Optical fibre cabling	TIA - 568.1-D Commercial building	TIA - 607-C Bonding and grounding telecommunications	TIA - 536-14-C Multi-mode fibre testing
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TIA - 568.4-D Broadband coaxial cabling and components	TIA - 758-B Customer-owned outside plant	TIA - 606-C Administration	TIA - TSB-155-A Support of 10Gbase-T on existing Cat.6
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TIA - 942-B Data centers	TIA - 862-B Intelligent building systems	TIA - TSB-5021 Guidelines for 2.5G and 5G on Cat5e and Cat6
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TIA - 1005-A Industrial premises	TIA - 5017 Physical network security
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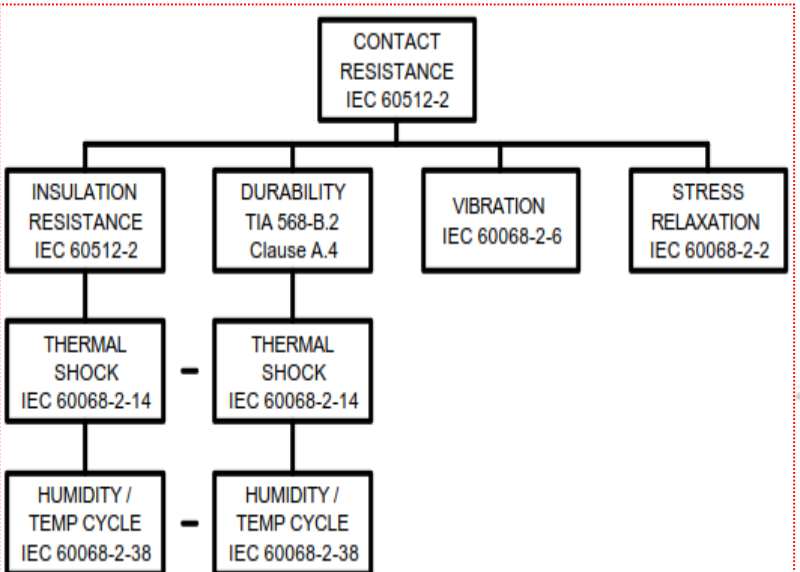
TIA - 1179-A Healthcare facilities
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TIA - 570-C Residential

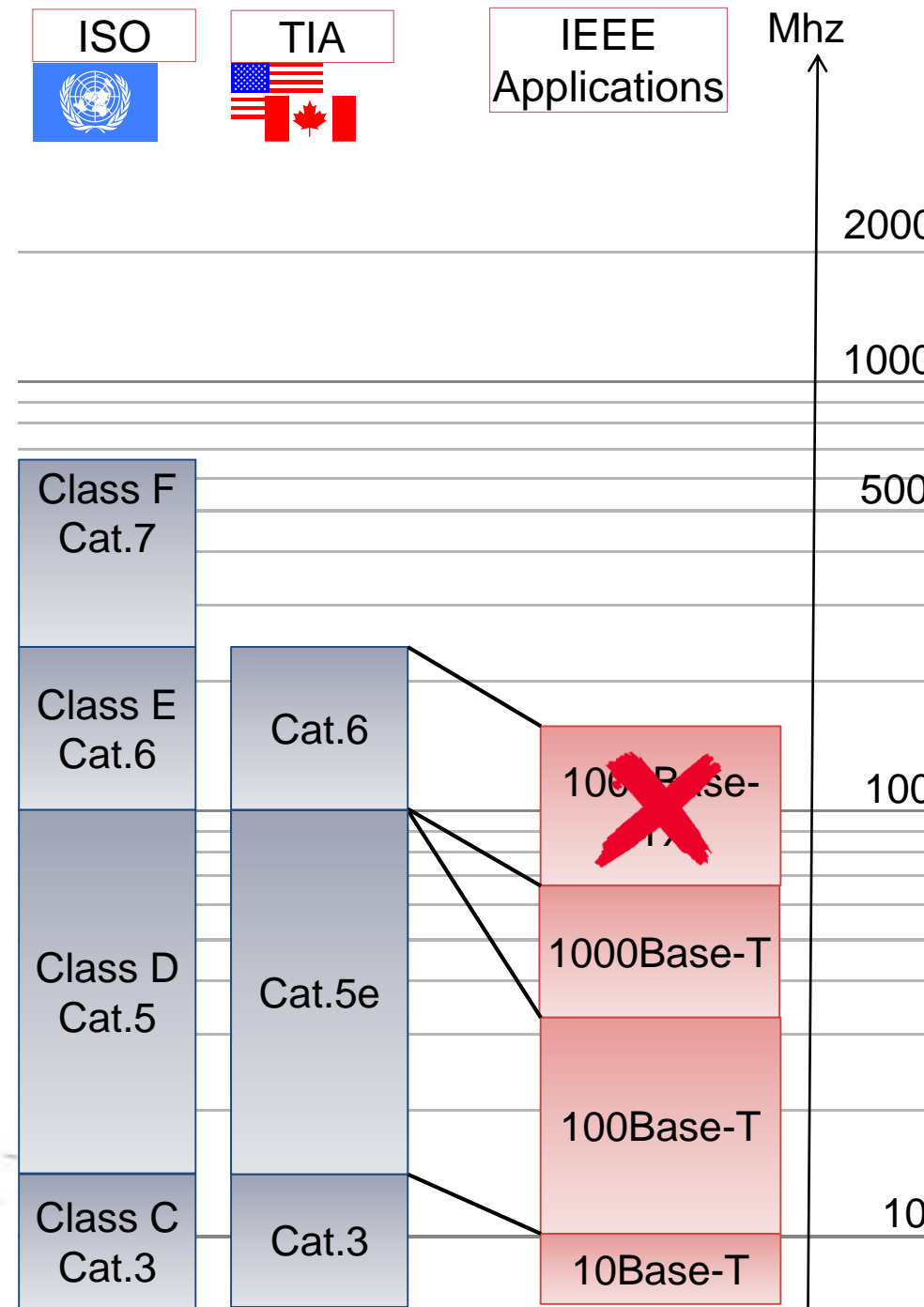
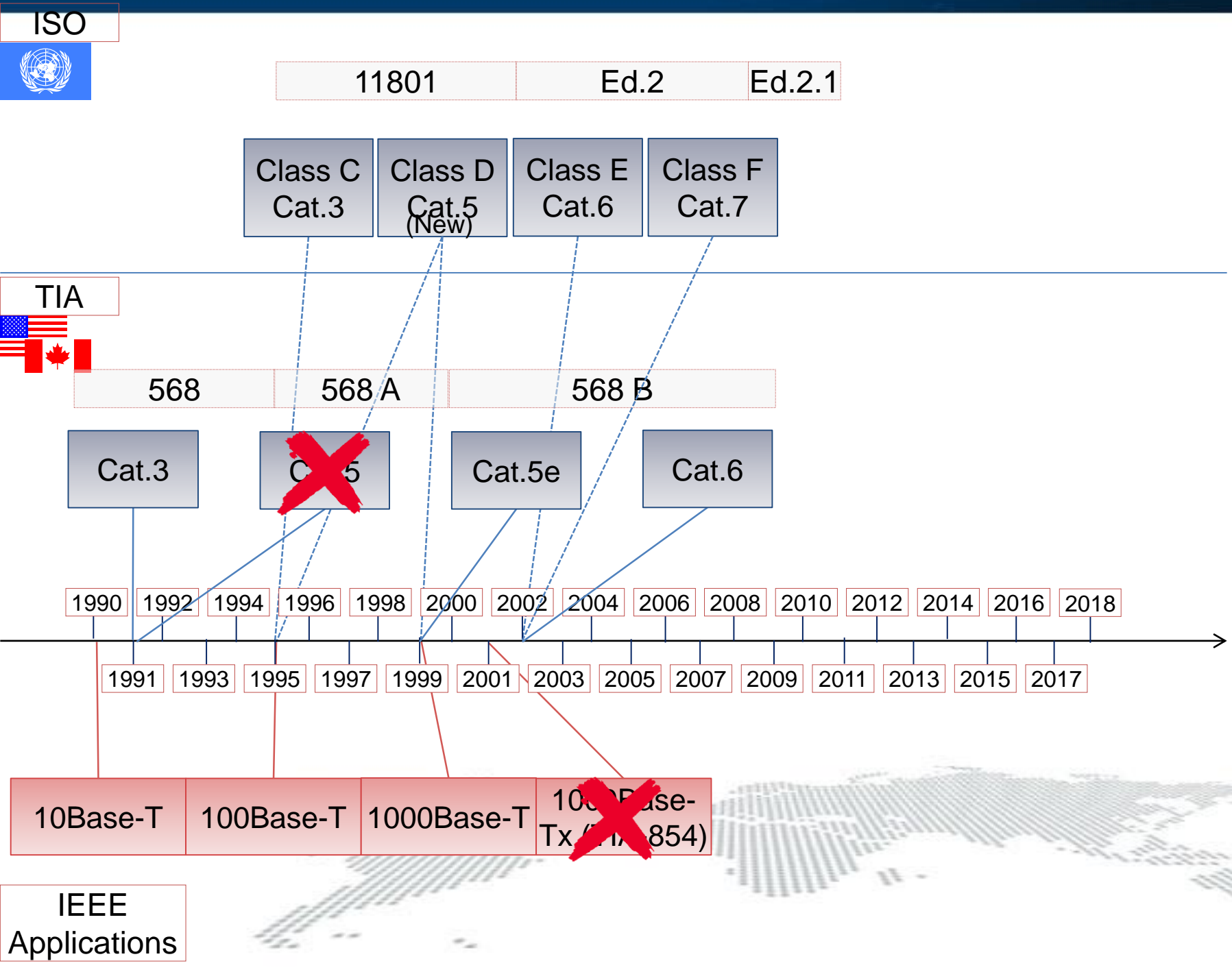
TIA - 4966 Educational facilities

TIA - 162-A Cabling for wireless access points
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TIA - 5018 Cabling for distributed antenna systems
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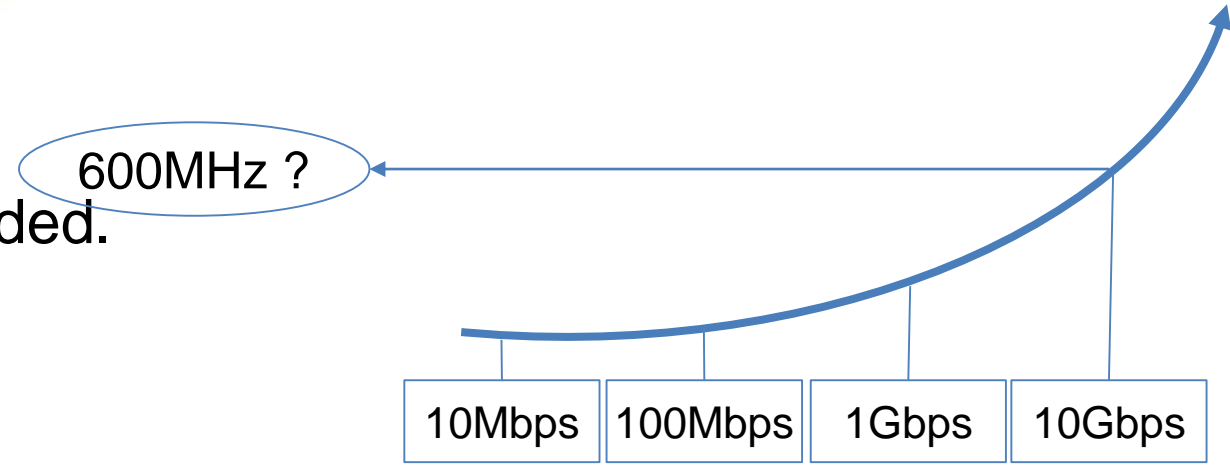


Copper Categories

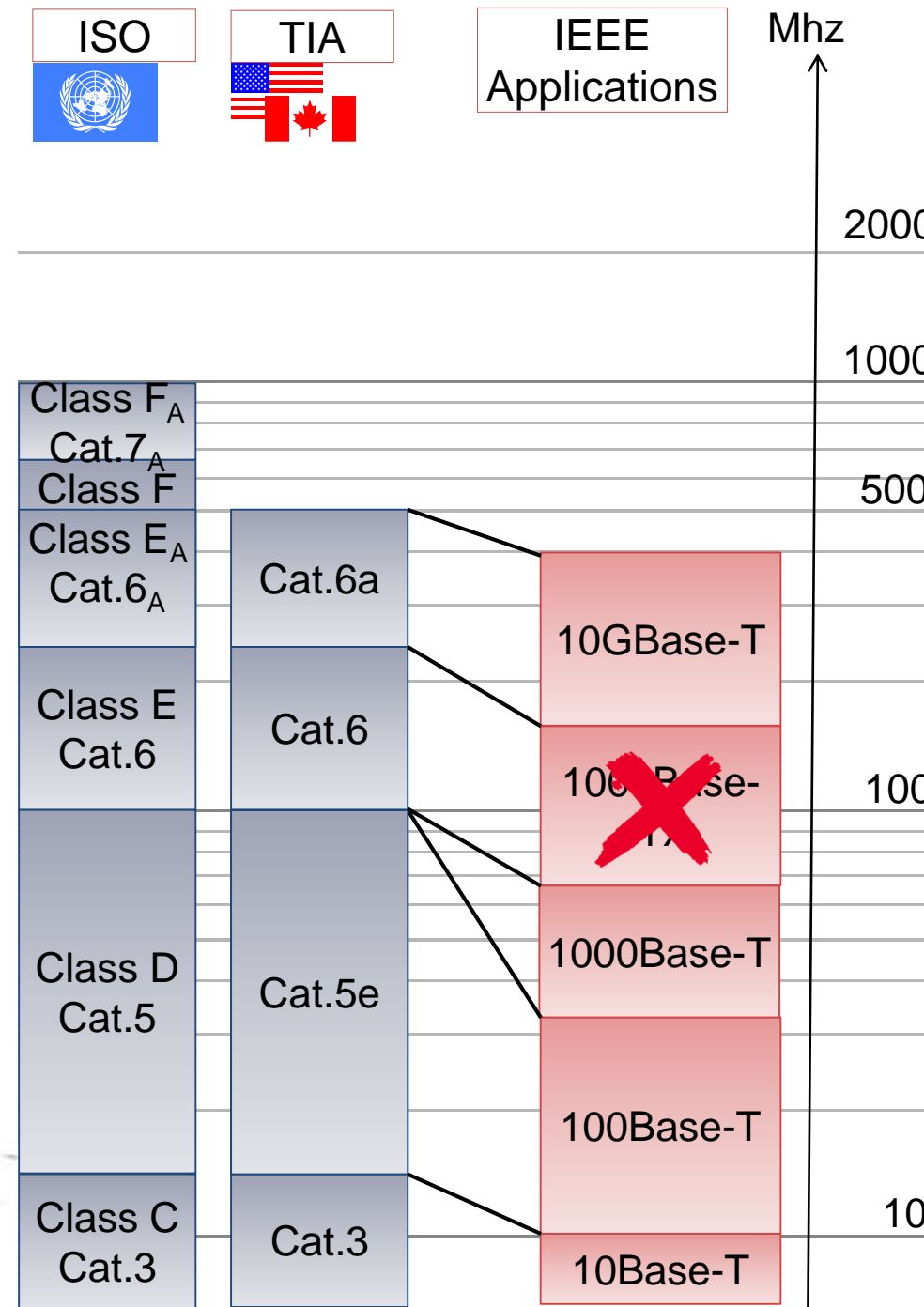
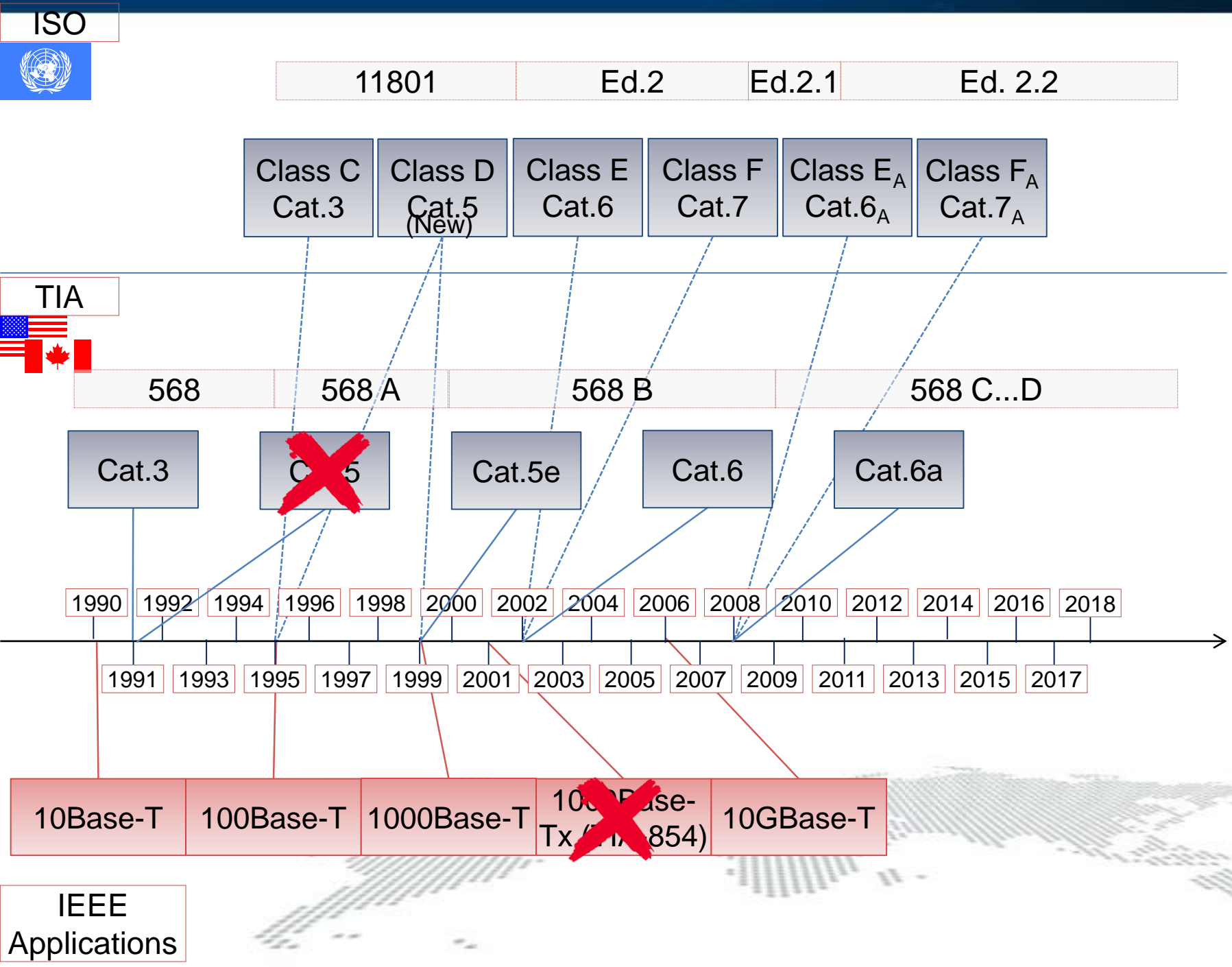


Category 7

- Designed for a future 10 Gigabit Ethernet.
- 600MHz definition was a “best guess”.
- Technology for 600MHz cable was impossible unless fully shielded.
- Technology for 600MHz RJ45 was deemed impossible.
- Category 7 was created with “PIMF” cable and “non-RJ45” connectors.



Copper Categories



IEEE 802.3bg 10GBase-T

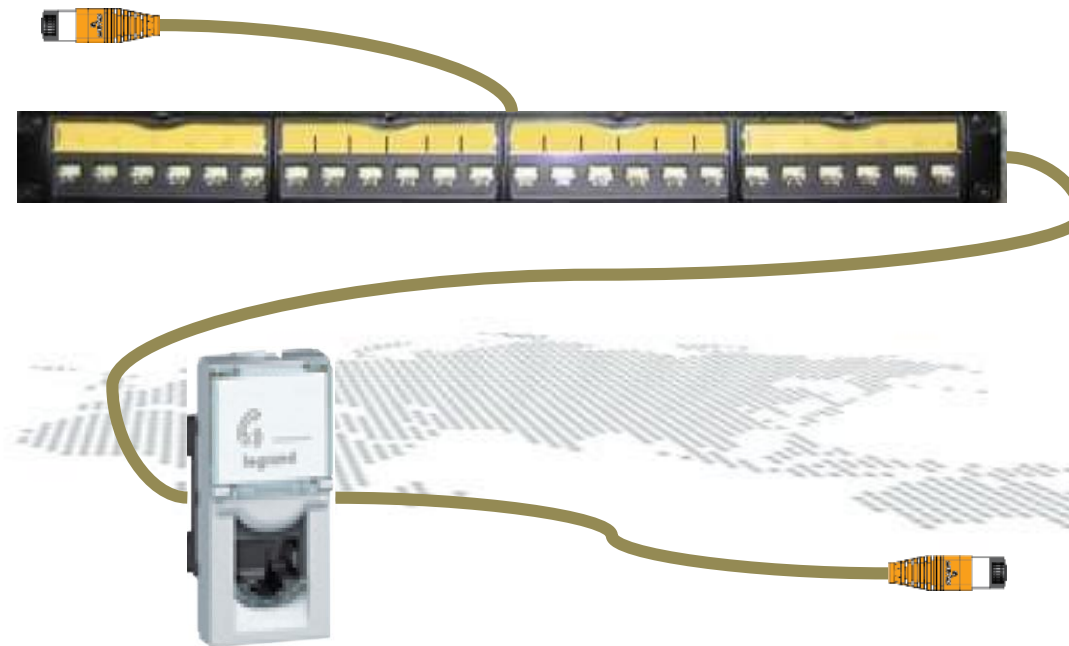
- 10G is ratified in 2006:

Category / Class	Compliance	Conditions
Cat.6 / Class E _A	Possible	Additional testing*
Cat. 6 _A / Class E _A	Yes	RJ45 connector
Cat.7 / Class F	Yes	Non-RJ45 connector

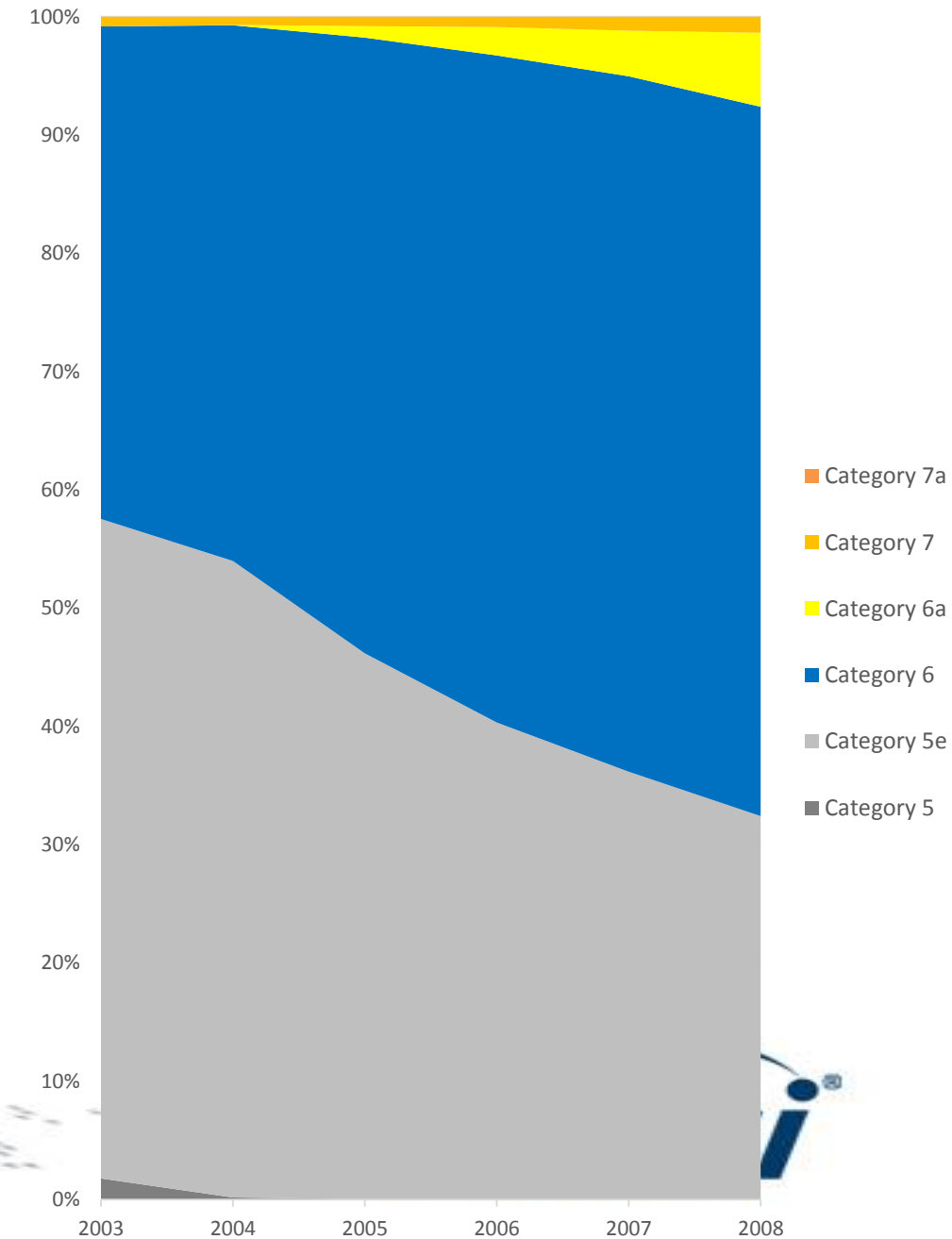
* Only for existing cabling. Re-Test in-channel up to 500MHz, and test Alien noise



Disturbed Cable



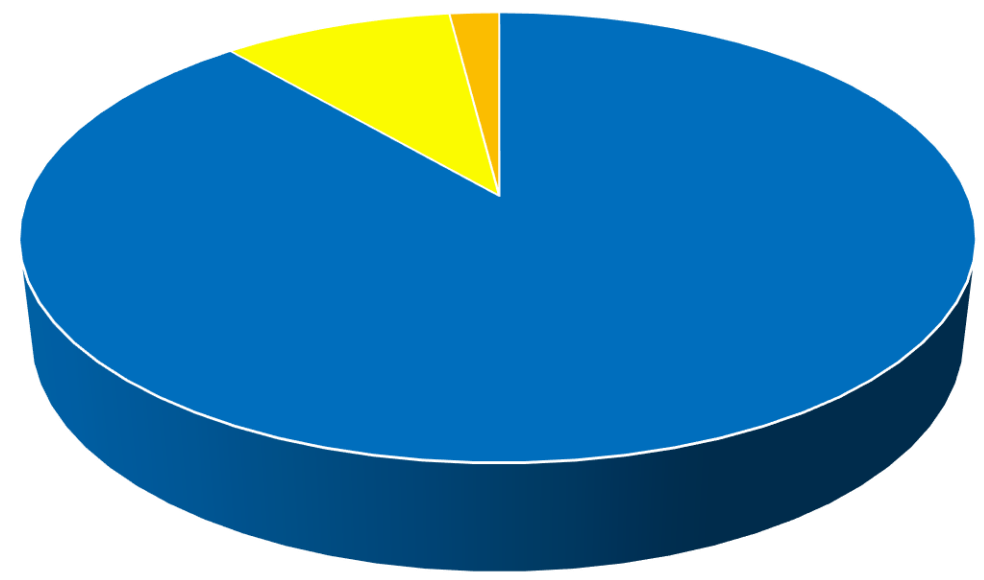
Cable Sales in % of market (BSRIA)



Category 7_A

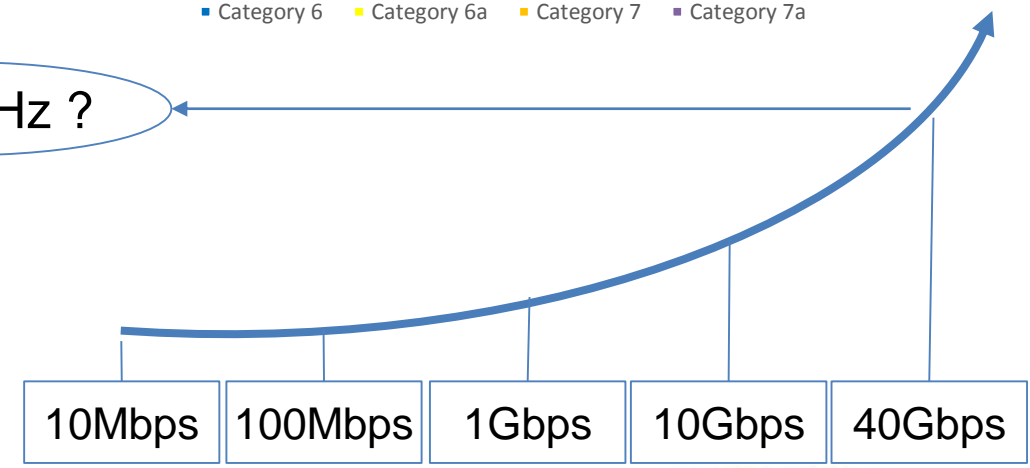
- No active equipment exists for 10G on Category 7 / Class F.
- So as soon as Cat6A is ratified, any cabling system for 10G but using connectors other than RJ45 is non competitive.
- Category 7A was created to offer a solution with the highest available frequency with the “non-RJ45” connectors. (about 1GHz in 2006)

2008 sales 10G compliant (BSRIA)

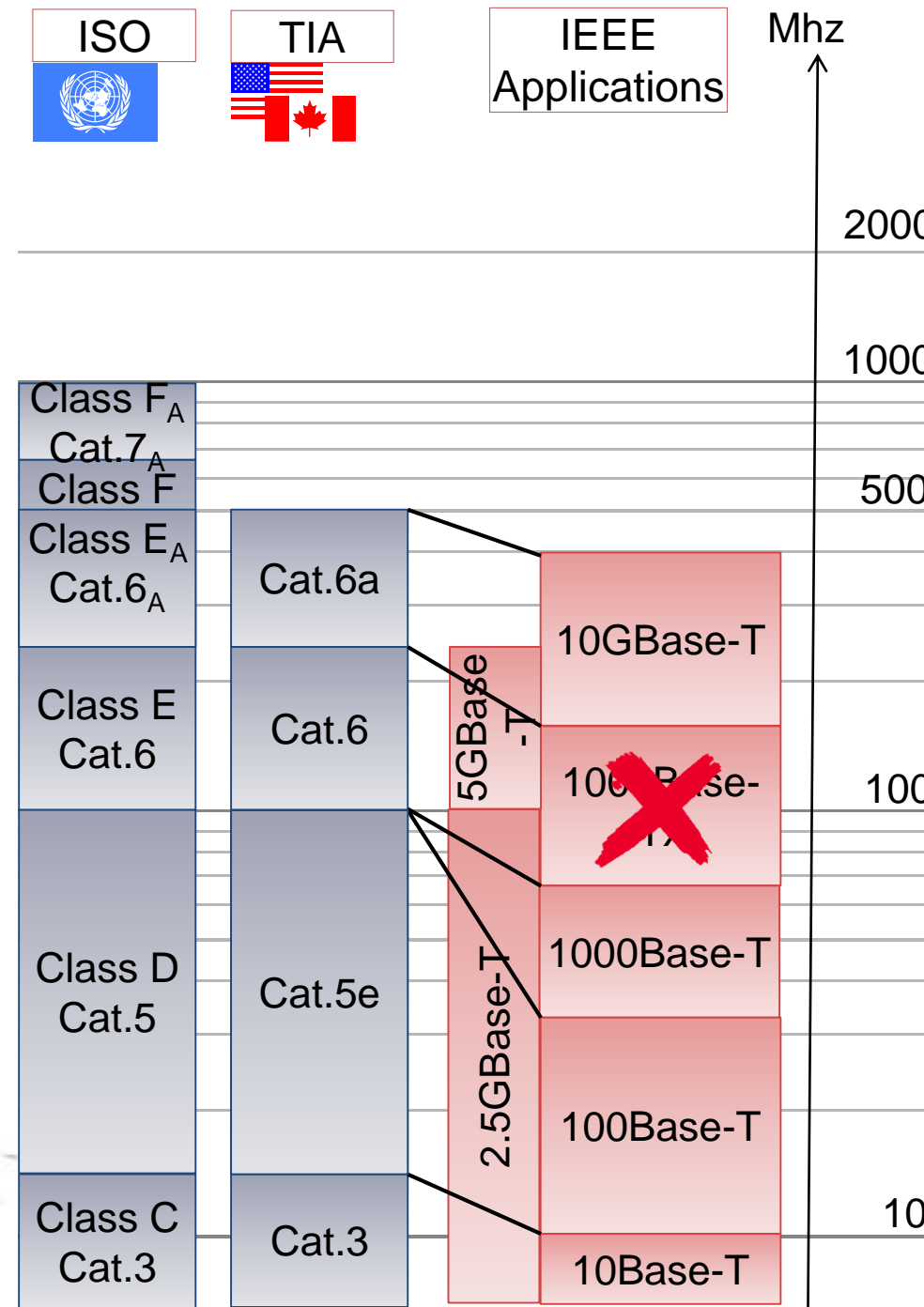
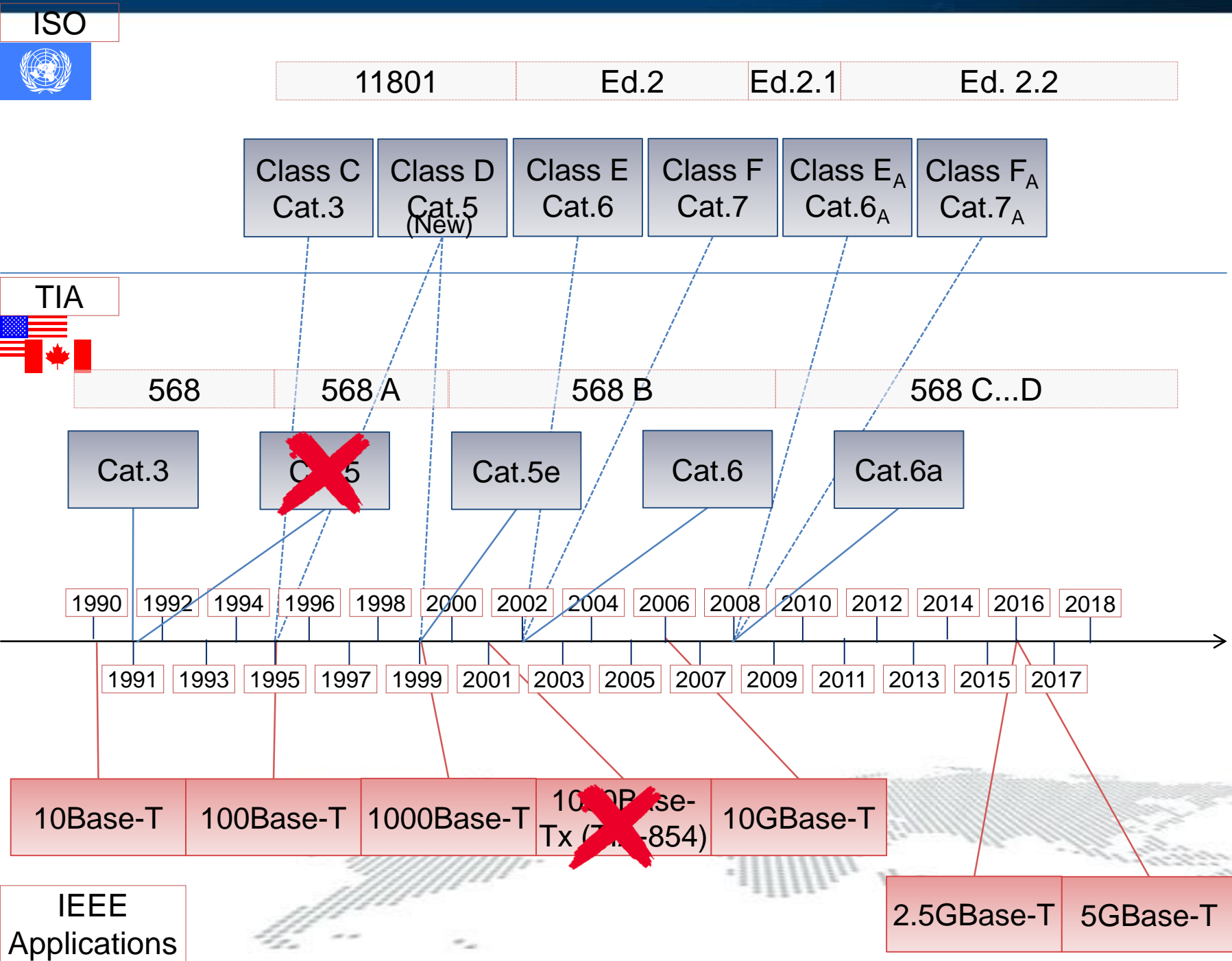


Category 6 Category 6a Category 7 Category 7a

1.6 -2GHz ?

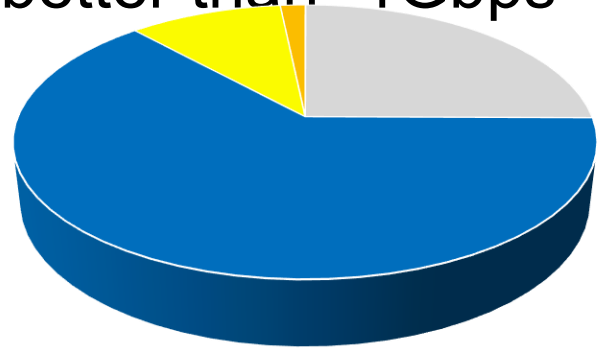


Copper Categories



Nbase-T 2.5G and 5G

- 802.11ac and 802.11ad, existing since 2013, offer 6.75Gbps wireless.
- Only Cat6a offers more than 1Gbps on cable.
- Wireless access points need to connect to existing cable with “better than” 1Gbps



■ Category 5
 ■ Category 5e
 ■ Category 6
■ Category 6a
 ■ Category 7
 ■ Category 7a



Disturbed Cable

Bundled cabling length 0m to 50m	Category 5e	Category 6	Category 6A
2.5GBASE-T			Assured
5GBASE-T Assured			Assured
Bundled cabling length 50m to 75m	Category 5e	Category 6	Category 6A
2.5GBASE-T			Assured
5GBASE-T Assured			Assured
Bundled cabling length 75m to 100m	Category 5e	Category 6	Category 6A
2.5GBASE-T			Assured
5GBASE-T Assured			Assured
ALSNR Risk	High	Medium	Low

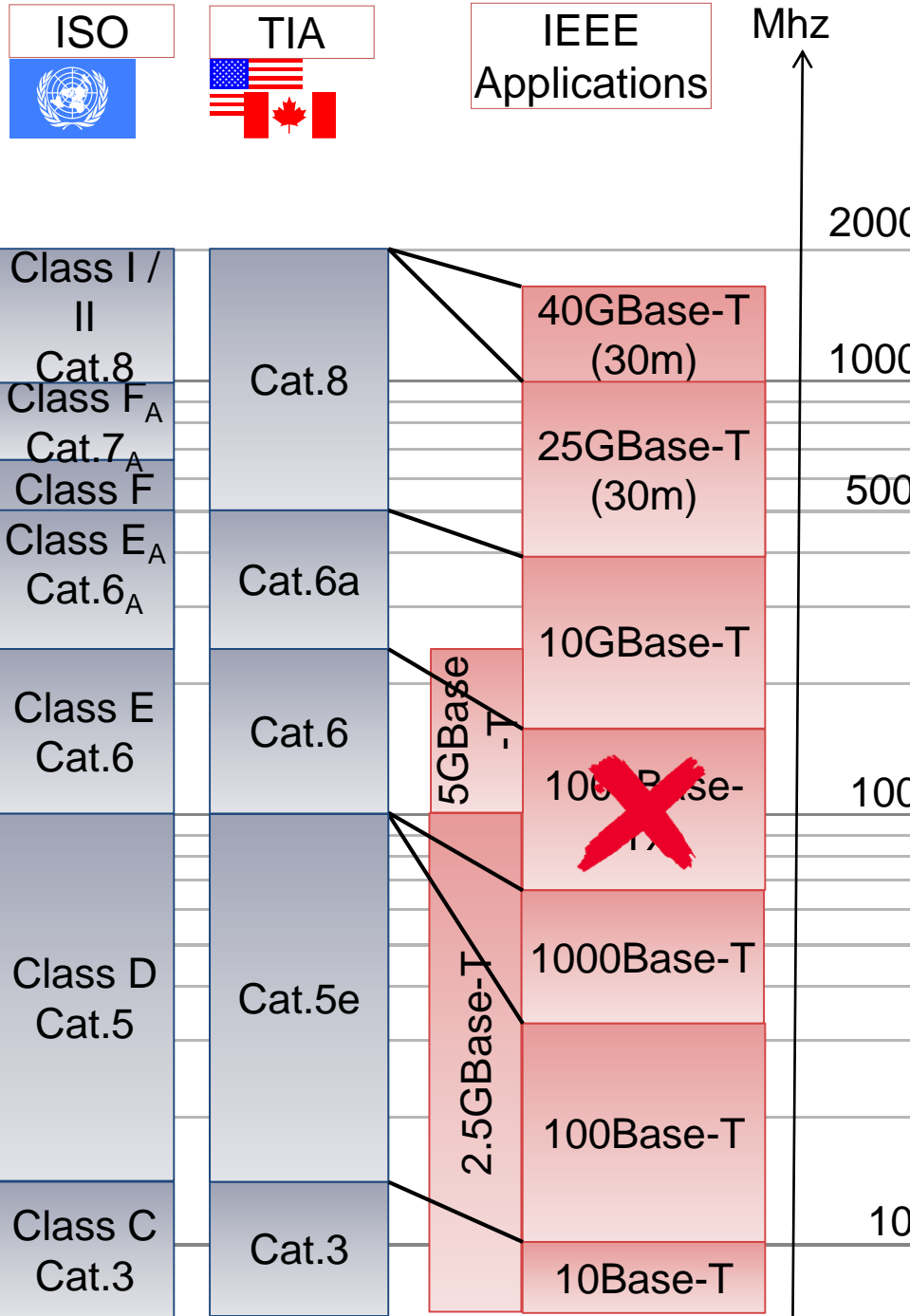
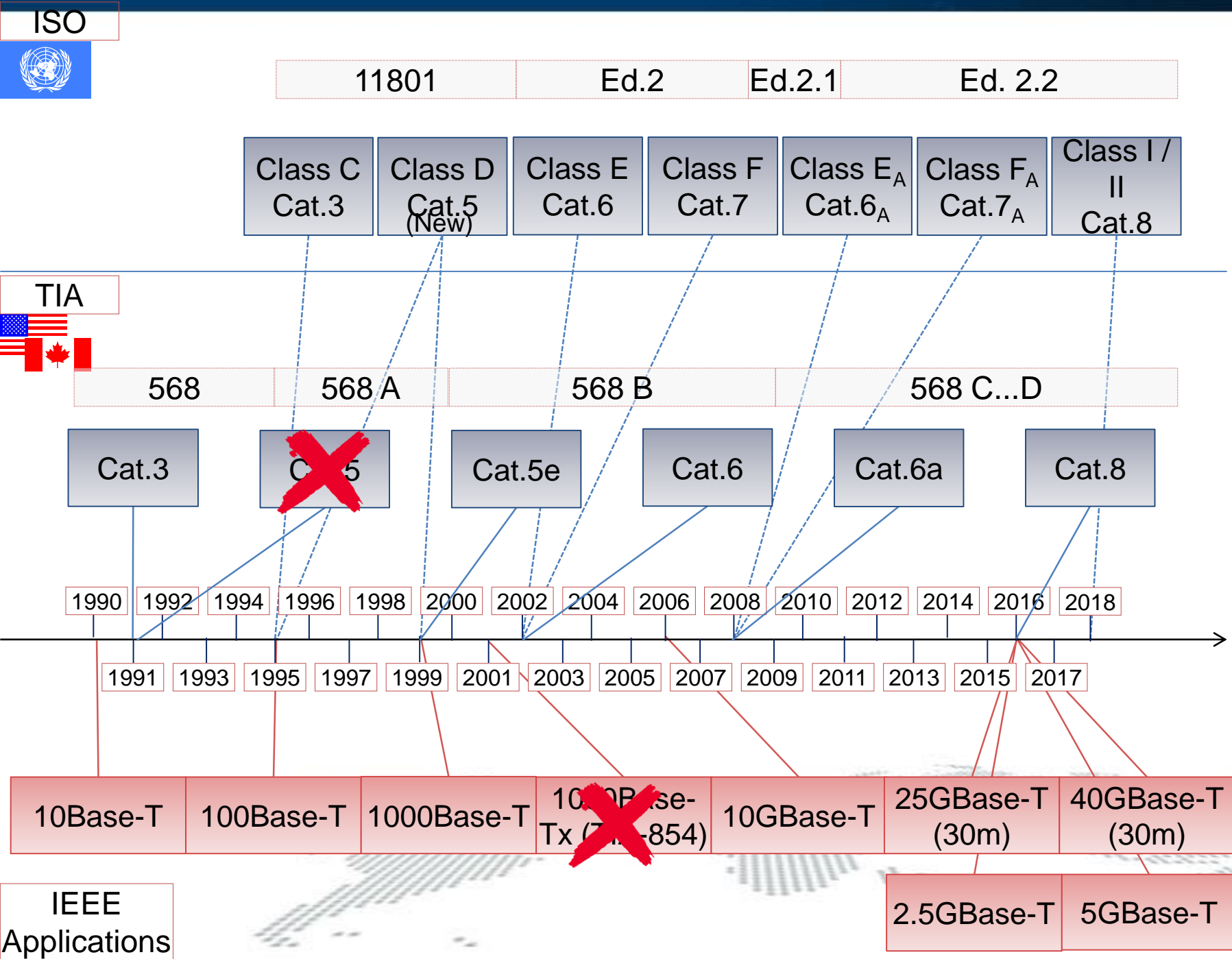
Table from NG-Base-T



6.77 Gbps

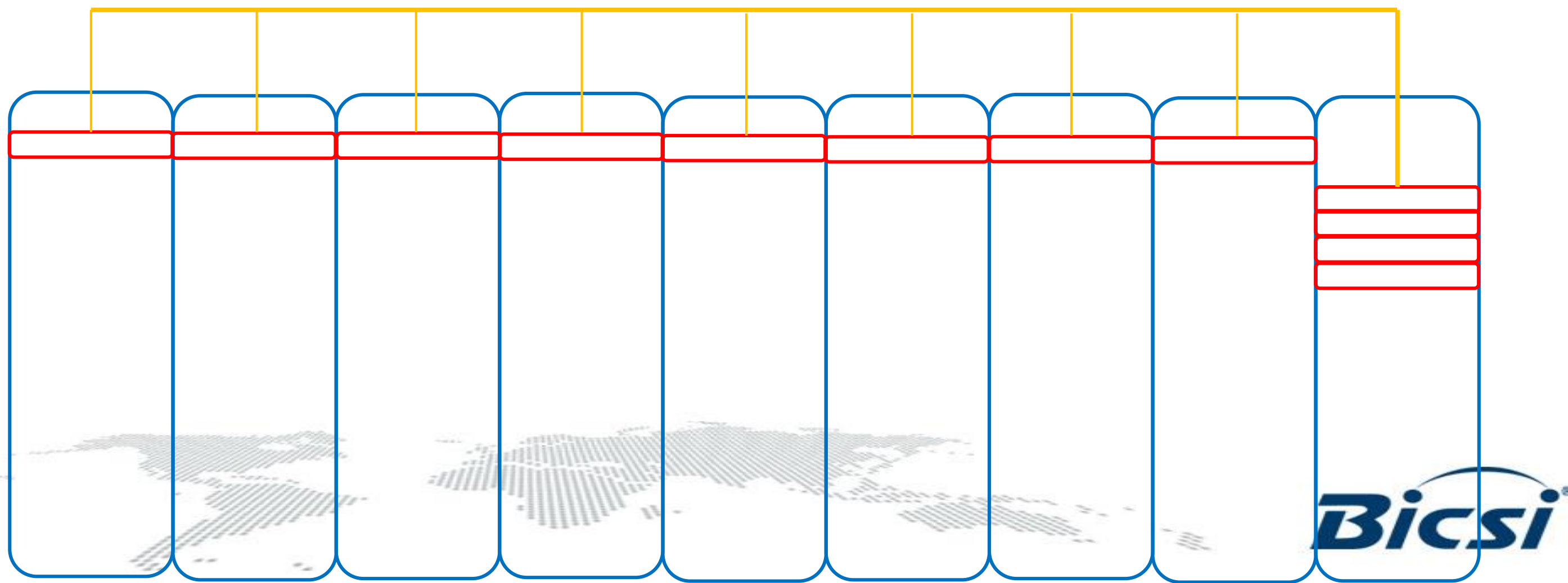
802.11ac

Copper Categories



25G and 40G

- IEEE 802.3bq 25Gbase-T and 40Gbase-T is designed for the horizontal cabling in datacenters.
- The maximum distance is 30m.



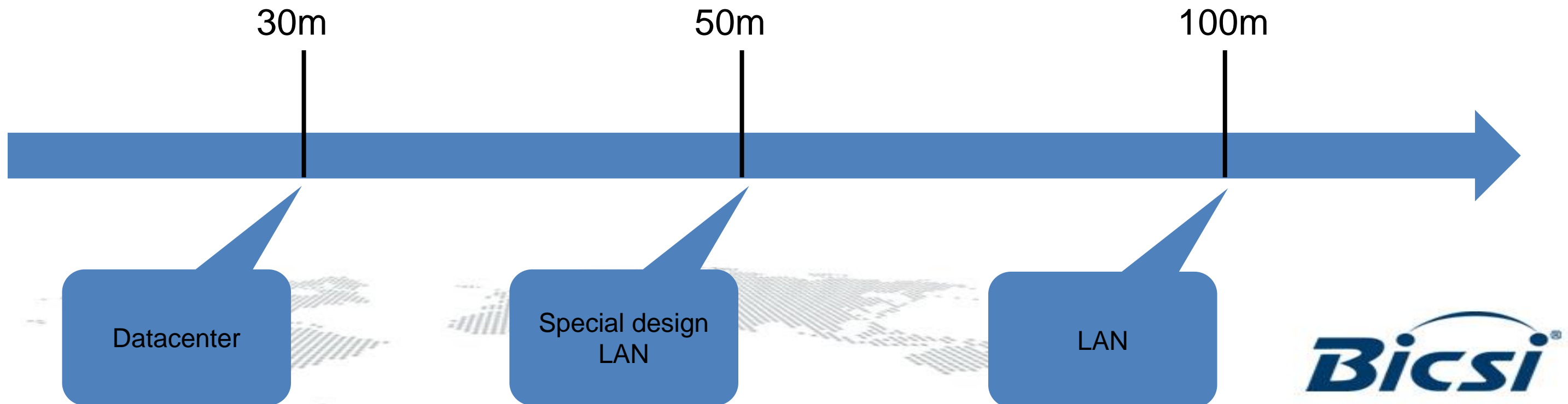
Cat.8, Class I and Class II

	Frequency	Distance	25 and 40 GBase-T	Cable	Connectors
TIA Cat.8	2 GHz	30m	Yes	F/UTP or S/FTP Cat.8	“RJ45” Cat.8
ISO Class I				Cat 8.1 = TIA Cat8	“RJ45” Cat.8.1 = TIA Cat.8
ISO Class II				S/FTP Cat.8.2	“Non-RJ45”



What's next?

- There is currently no work on any future Category 9.
- 40G is limited to 30m on category 8.
- Best solution for LAN is currently 10G, working on Category 6_A.
- But 25G could work for longer distance on Cat.8. (will not work on Cat.7_A)
- Currently in development in the standards: New 25G on Category 8 for 50m.



Agenda

1- Copper Systems

2- Fiber Systems

Multimode vs. Singlemode

10GBASE-LR SFP+ transceiver module for SMF, 1310-nm wavelength, 10km, LC duplex connector



Price: **\$395.00**
Model/Part #: SFP-10G-LR
Availability: In Stock
Ships: In 24 hours
Warranty: Lifetime

Qty: **+ Add to Cart** - OR - [Add to Wish List](#)
[Add to Compare](#)

☆☆☆☆☆ [0 reviews](#) | [Write a review](#)

Singlemode for distance,
multimode for price

10GBASE-SR SFP+ transceiver module for MMF, 850-nm wavelength, 300m, LC duplex connector



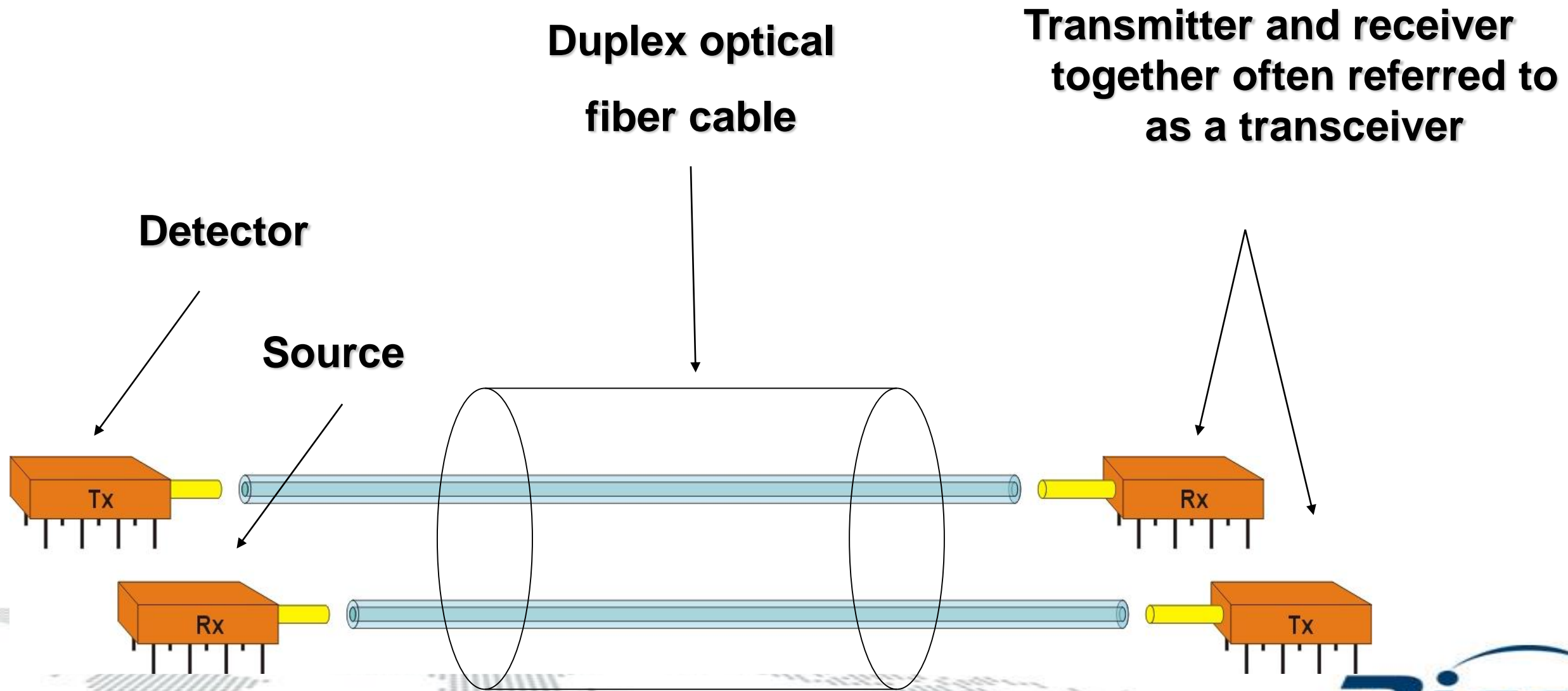
Price: **\$145.00**
Model/Part #: SFP-10G-SR
Availability: In Stock
Ships: In 24 hours
Warranty: Lifetime

Qty: **+ Add to Cart** - OR - [Add to Wish List](#)
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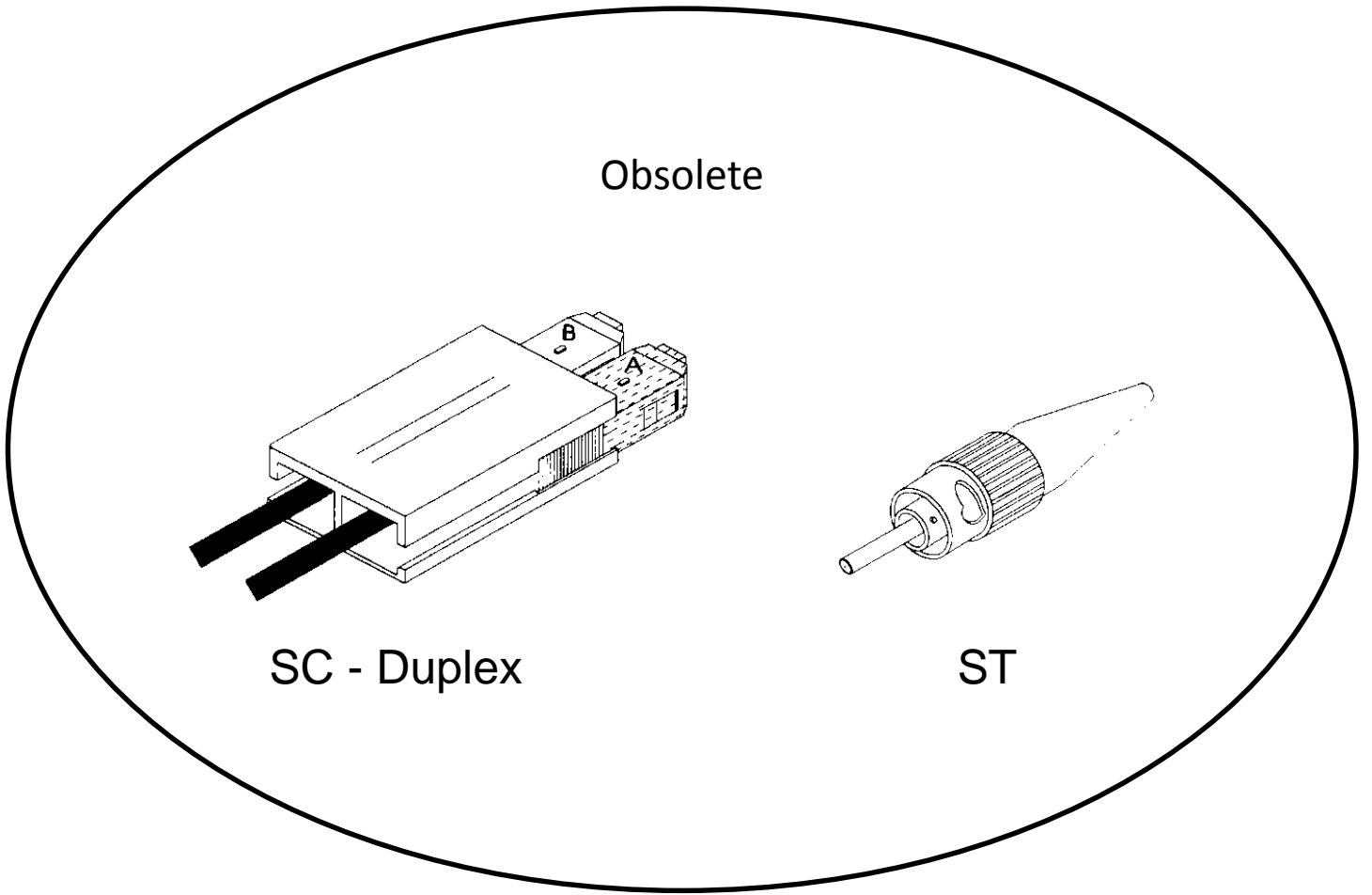


Duplex transmission



Connector choice

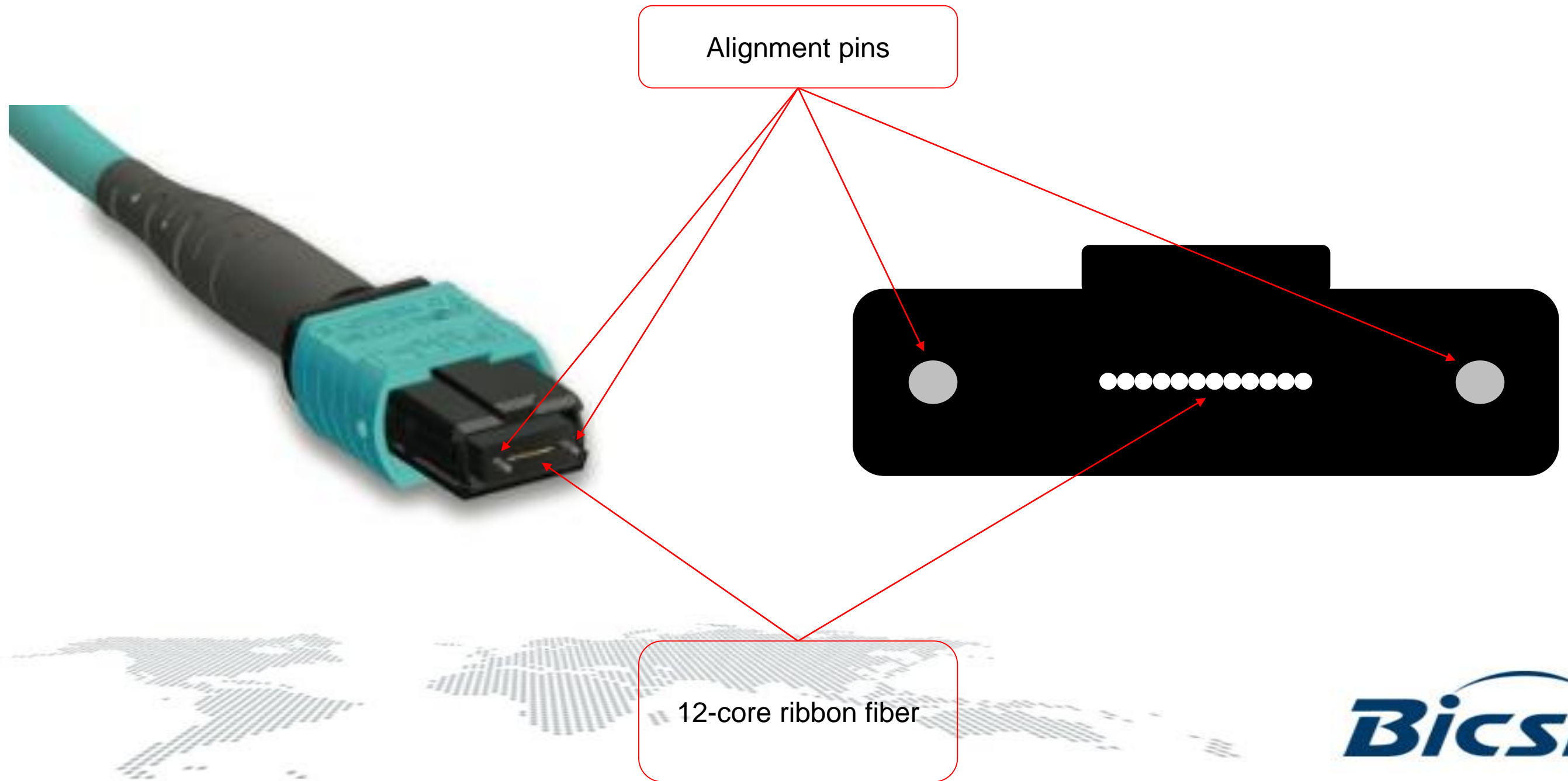
LC



SC - Duplex

ST

Alternate: the MPO

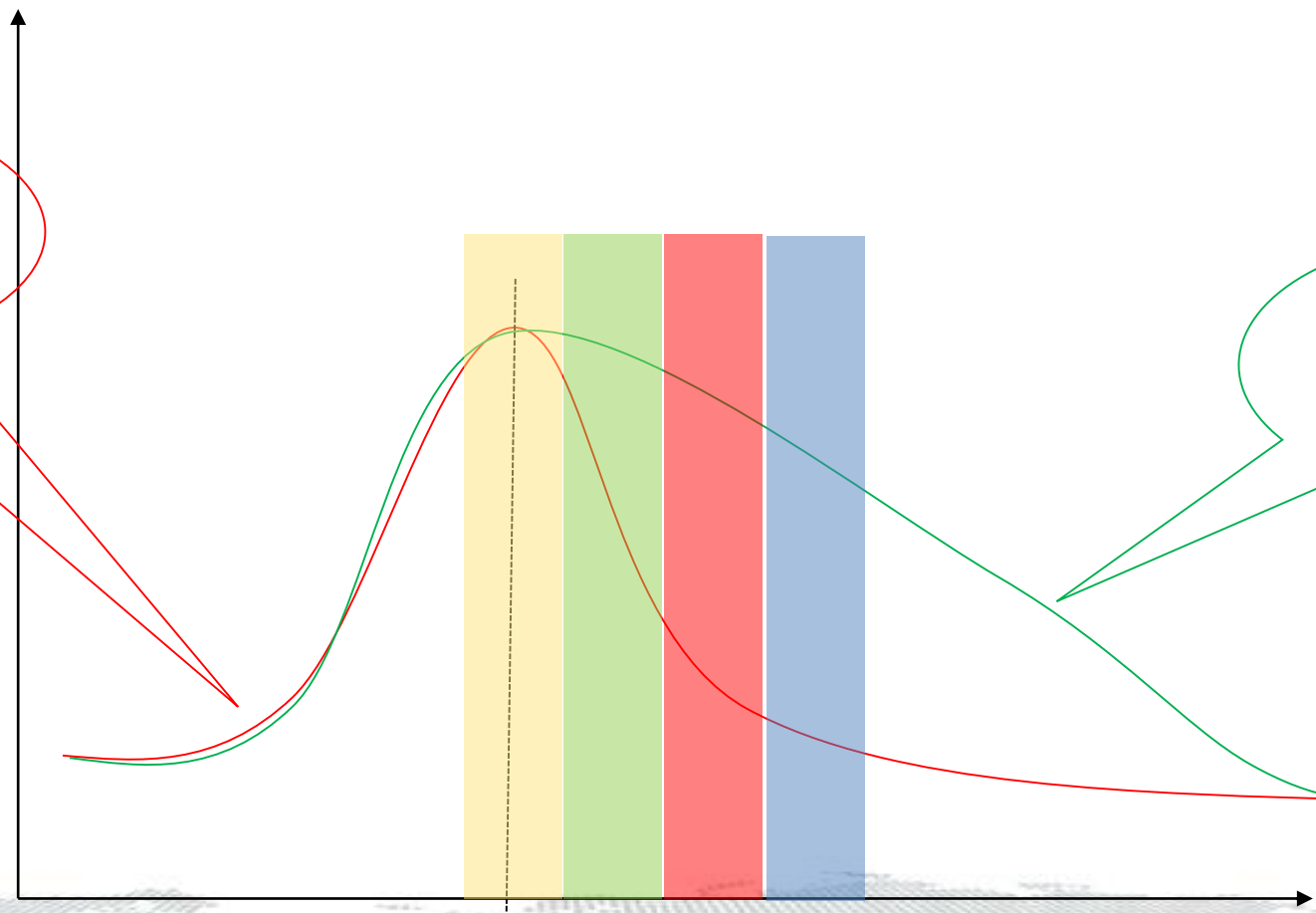


Increasing the performance on MM Fiber

	OM3 300m	OM4 400m	OM3 100m	OM4 150m	OM3 70m	OM4 100m	OM3 70m	OM4 100m
	LAN 10G VCSEL (NRZ)	DC 10G VCSEL (NRZ)	DC 10G VCSEL (NRZ)	DC 25G VCSEL (NRZ)	DC 25G VCSEL (NRZ)	DC 50G VCSEL (PAM4)	DC 50G VCSEL (PAM4)	DC 100G VCSEL (PAM4)
10G	●●							
25G				●●				
40G		●●●●●●●●●●						
		●● (WDM: Different distances)						
50G						●●		
100G		●●●●●●●●●● ●●●●●●●●●●		●●●●●●●●		●● (WDM: Different distances)		●●
				●● (WDM: Different distances)				
200G						●●●●●●●●		●●●●
						●● (WDM: Different distances)		
400G				●●●●●●●●●● ●●●●●●●●●●		●●●●●●●●		●●●●●●●● ?
				●●●●●●●● (WDM: Different distances)		●●●●●●●● (WDM: Different distances)		

OM5 Fiber

Performance



OM3 / OM4 Fiber

OM5 Fiber

850nm

Wavelength



Singlemode New Developments

	25G LASER (NRZ)	40G LASER (NRZ)	50G LASER (PAM4)	100G LASER (NRZ)
10G				
25G	●●			
40G		●●		
50G			●●	
100G				●●
200G			●●●●●●●●	
400G			●●	
			●●	●●●●●●●●

8 wavelengths



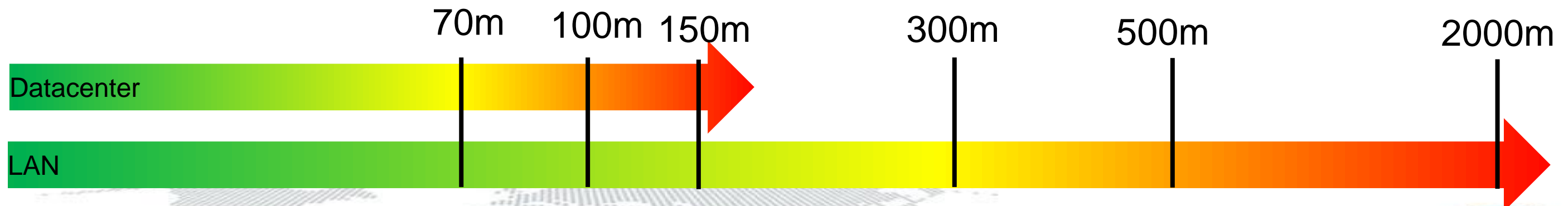
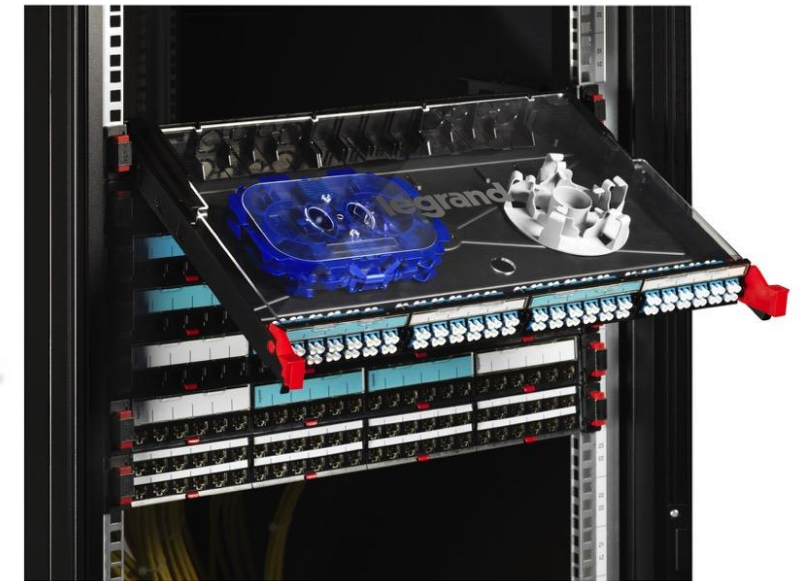
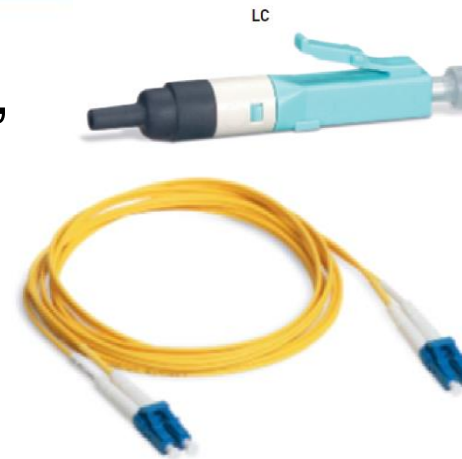
Fiber Channel

Rate	Multimode	Singlemode
16 GFC	●●	●●
32 GFC	●●	●●
64 GFC <i>(under discussion)</i>	●●	●●
128 GFC	●●●●○●●●●	●●●●○●●●● ●●
256 GFC <i>(under discussion)</i>	●●●●○●●●●	●●●●○●●●● ●●



What's next?

- Continued Higher data rates in the datacenter.
- New applications based on signals of 25G, 50G and 100G, not on 40G.
- Parallel optics use 4, 8 16 cores instead of the base 12 originally in the MPO connectors.
- (financial) Distance limit between parallel optics and wavelength multiplexing not clear yet.
- For backbone cabling based on 2-core cabling, OM5 seems to have far more probability of future application than OM3 or OM4.



Thank You

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