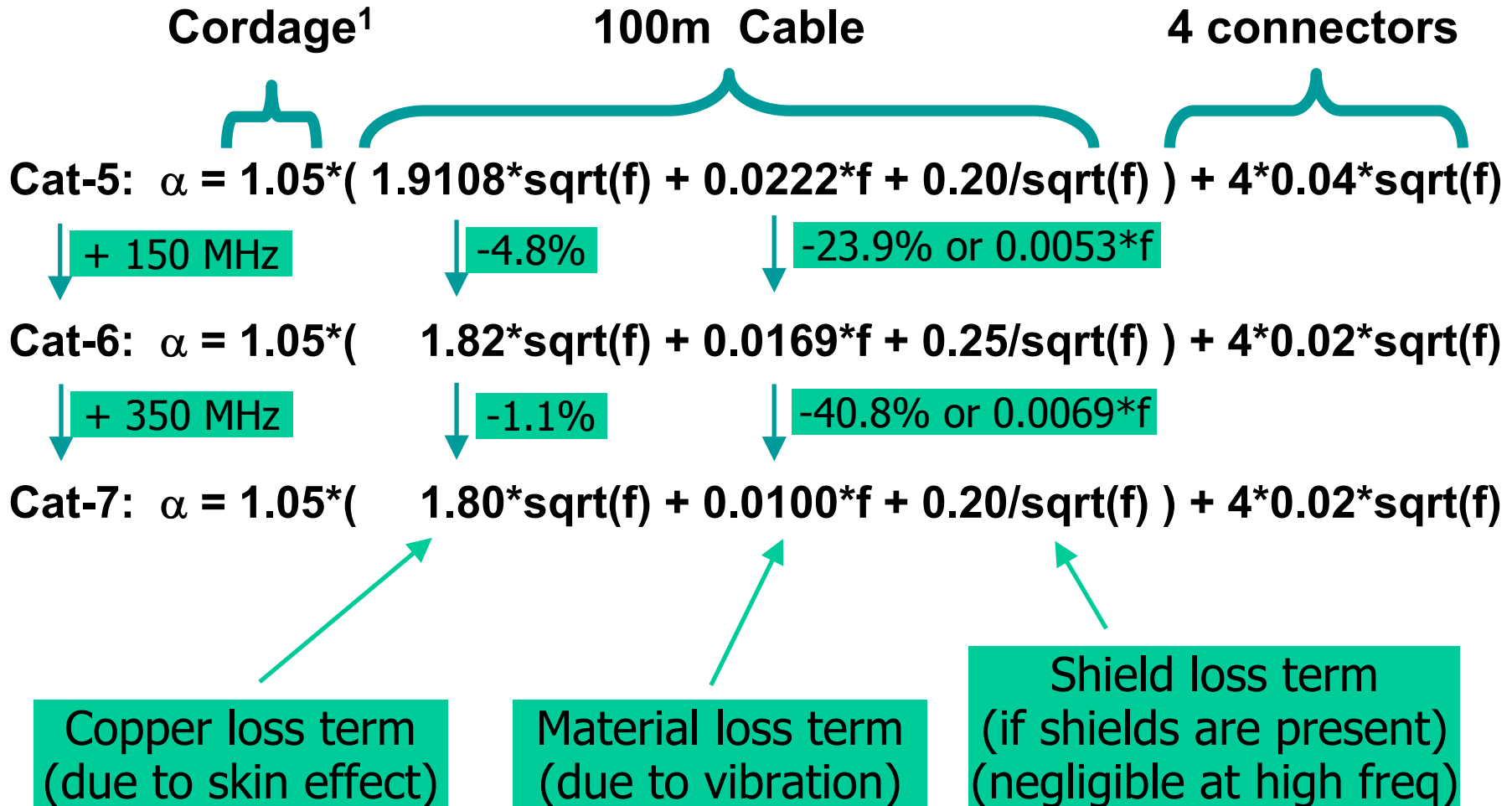# A closer look at Channel Insertion Loss

Presented to: 10GBASE-T Task Force – March 2004
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Supporters (list to be updated)

- **Bob Kenny – GM, Krone**

Breaking down the ISO channel loss equation

Cordage[1]   **100m Cable**   **4 connectors**

Cat-5: $\alpha = 1.05*(1.9108*\text{sqrt}(f) + 0.0222*f + 0.20/\text{sqrt}(f)) + 4*0.04*\text{sqrt}(f)$

+ 150 MHz   -4.8%   -23.9% or 0.0053*f

Cat-6: $\alpha = 1.05*(1.82*\text{sqrt}(f) + 0.0169*f + 0.25/\text{sqrt}(f)) + 4*0.02*\text{sqrt}(f)$

+ 350 MHz   -1.1%   -40.8% or 0.0069*f

Cat-7: $\alpha = 1.05*(1.80*\text{sqrt}(f) + 0.0100*f + 0.20/\text{sqrt}(f)) + 4*0.02*\text{sqrt}(f)$

Copper loss term
(due to skin effect)

Material loss term
(due to vibration)

Shield loss term
(if shields are present)
(negligible at high freq)

1 Cordage may have up to 50% more loss per meter than cable. Therefore 10 meters of
cordage has the same attenuation as 15 meters of cable resulting in a scaling factor of 1.05

Attenuation of Cat-5e vs Cat-6 Channels
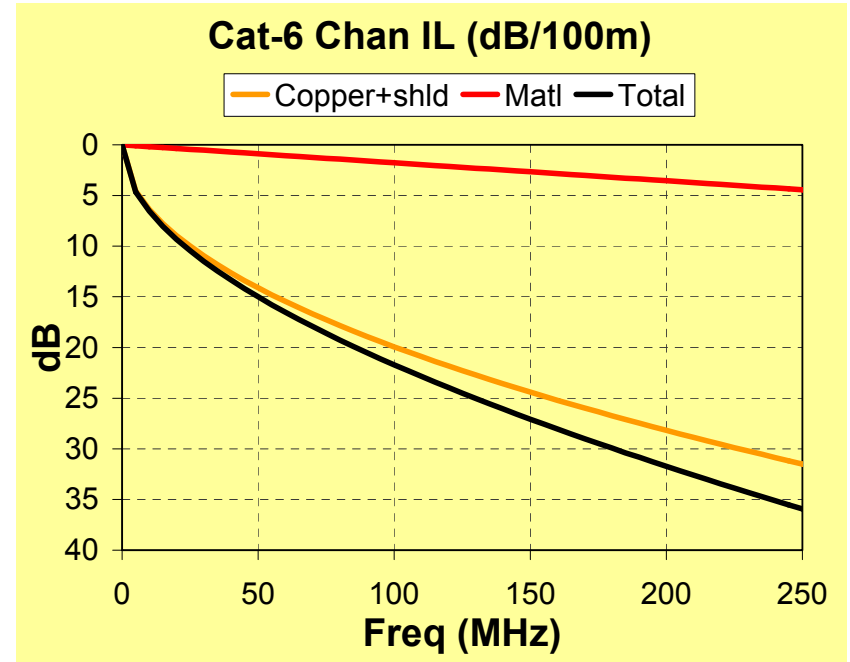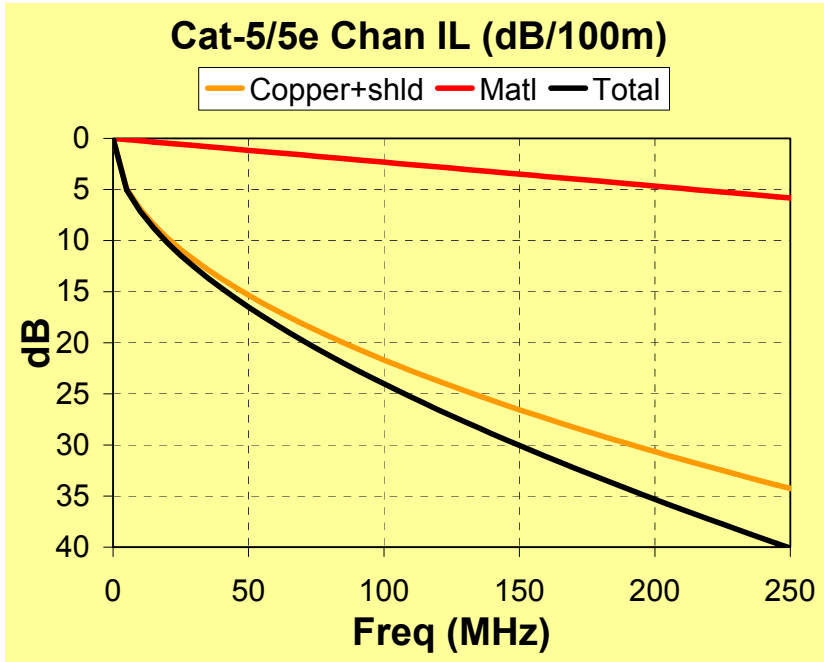
	Attenuation at 100 MHz			
	Cu+sh	Matl	Total	% matl
cat-5/5e	21.68	2.33	24.01	9.7%
cat-6	19.94	1.77	21.71	8.2%
dB red:	1.75	0.56	2.30	
% red:	8.1%	23.9%	9.6%	

	Attenuation at 250 MHz			
	Cu+sh	Matl	Total	% matl
cat-5/5e	34.27	5.83	40.09	14.5%
cat-6	31.50	4.44	35.93	12.3%
dB red:	2.77	1.39	4.16	
% red:	8.1%	23.9%	10.4%	

- **Most of the attenuation improvement from cat-5e to cat-6 was obtained via lower copper loss but material loss was also improved**

Attenuation of Cat-6 vs Cat-7 Channels

Cat-6 Chan IL (dB/100m)
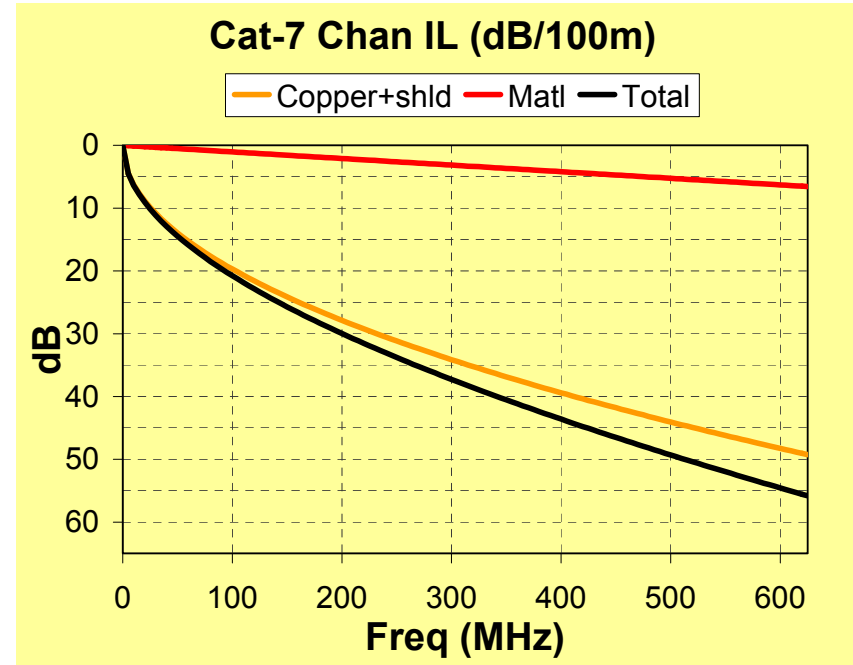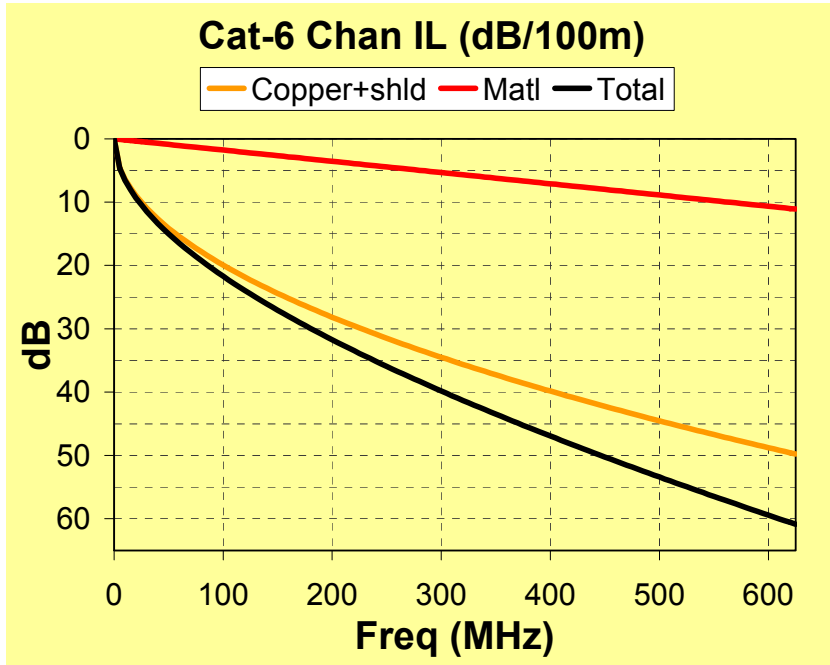
Attenuation at 250 MHz				
	Cu+sh	**Matl**	**Total**	**% matl**
cat-6	31.50	4.44	35.93	12.3%
cat-7	31.16	2.63	33.79	7.8%
dB red:	0.34	1.81	2.15	
% red:	1.1%	40.8%	6.0%	

Attenuation at 625 MHz				
	Cu+sh	**Matl**	**Total**	**% matl**
cat-6	49.79	11.09	60.88	18.2%
cat-7	49.26	6.56	55.82	11.8%
dB red:	0.53	4.53	5.06	
% red:	1.1%	40.8%	8.3%	

- **As maximum specified frequency range increases, it is more optimum to lower loss by improving material selection**

Conclusion

- **In optimizing cables the designer considers:**
  - **Insertion loss at the highest relevant frequency**
  - **Other electrical performance parameters to achieve system performance targets**
  - **Mechanical properties**
  - **Fire performance**
  - **Cost**

- **As the relevant frequency range increases, the relative importance of material loss increases thus favoring better materials in the optimization**

- **As we extend Cat-6 to 625 MHz, tightening the insertion loss specification to Cat-7 is a very cost effective way to improve system performance**