Bottom-Up Analysis of Medium and High Loss AUI

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802.3dj Task Force Meeting

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Overview

- Goal
- 1 RU switch implementation
- PCB, package, cable losses
- Various AUI and PPI implementations
- 100G AUI loss budget
- 200G AUI bottom-up loss analysis
- Summary.

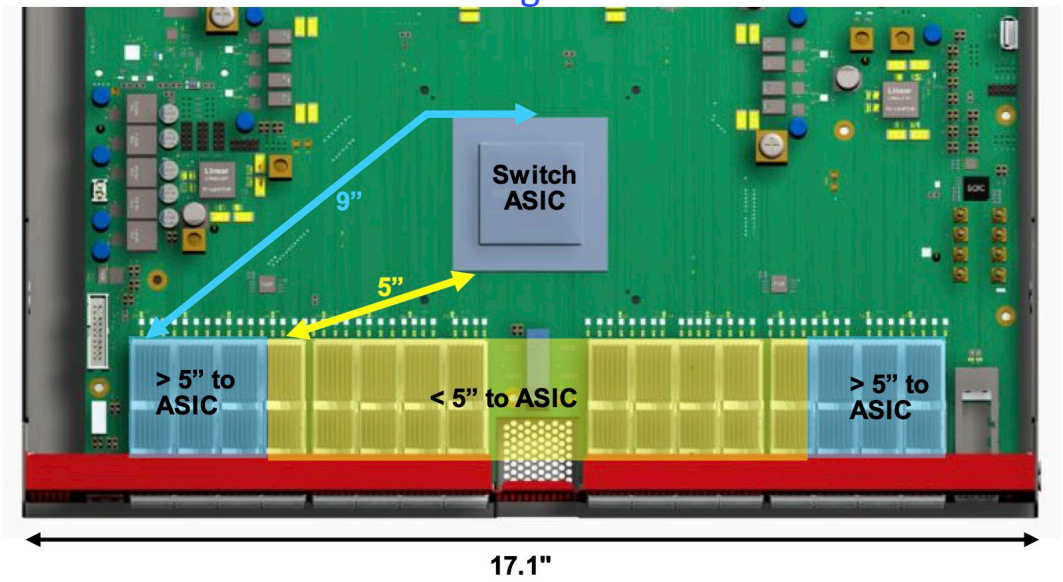
Goal

- **Illustrate various loss budgets for medium and high loss design types.**

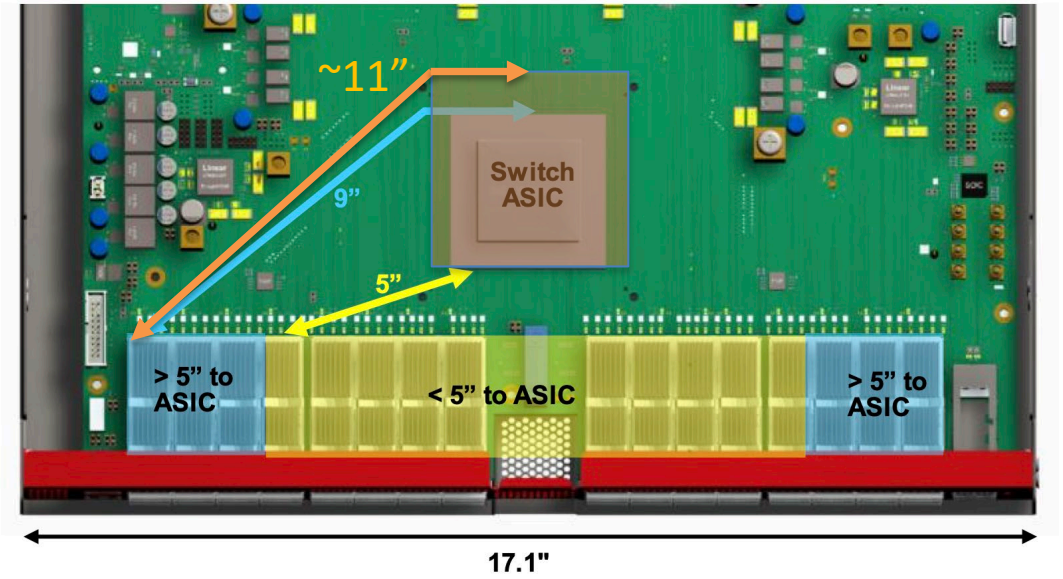
1RU Switch Implementation

- **To support convention PCB implementation in the 802.3ck CL120G was defined based on 11.9 dB or ~9” of PCB on Megtron 7 with 1.2 dB/in per recommendation [stone_3ck_01a_0518]**
  - A 51.2T switch will have to use ~90x90 package vs stone assumed package of ~69x69
  - Considering larger package to connect balls on the N side require at least 11”.

Stone Hypothetical 25.6T Switch
Package ~69x69



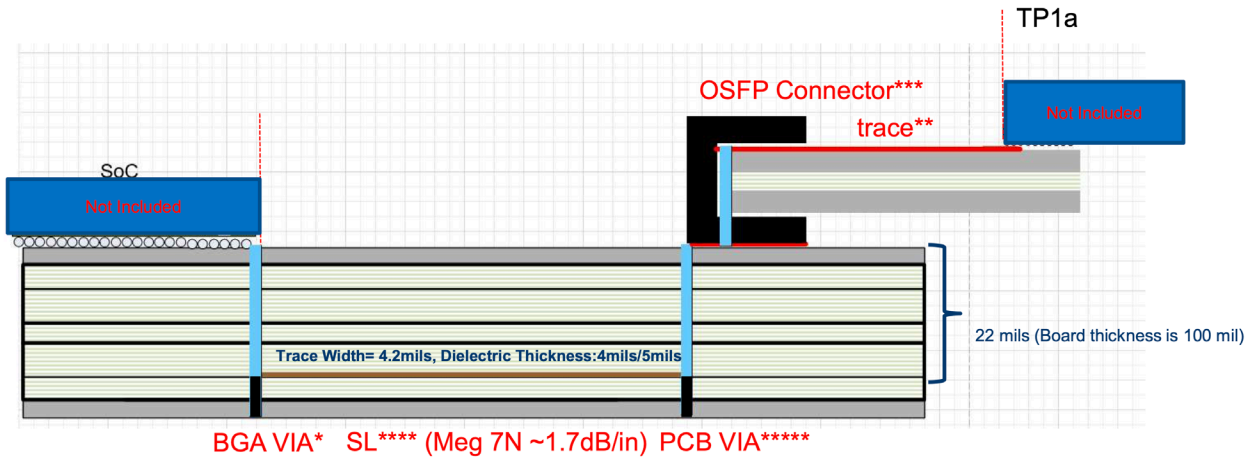
Hypothetical 51.2T Switch
Package ~90x90



NIC Channel Implementation

- **akinwale_3df_01_20220502 (see figure) does not mention the length of NIC channel but is estimated to be ~5" @1.7 dB/in at 53 GHz**
  - Considering NICs are cost sensitive, and the loss is < AUI Type-II with cabled host the loss assumed is 1.8 dB/in with 15 dB from TP0-TP1a instead of assumed 13 dB by Akinwale
  - Results generally failed 3 dB by over 1 dB for pre-FEC BER 1E-5
  - At pre-FEC BER of 1E-4, 2 out of 8 channels failed 3 dB COM even NIC card my benefit operating at pre-FEC BER higher than 1E-5!

Channel Description

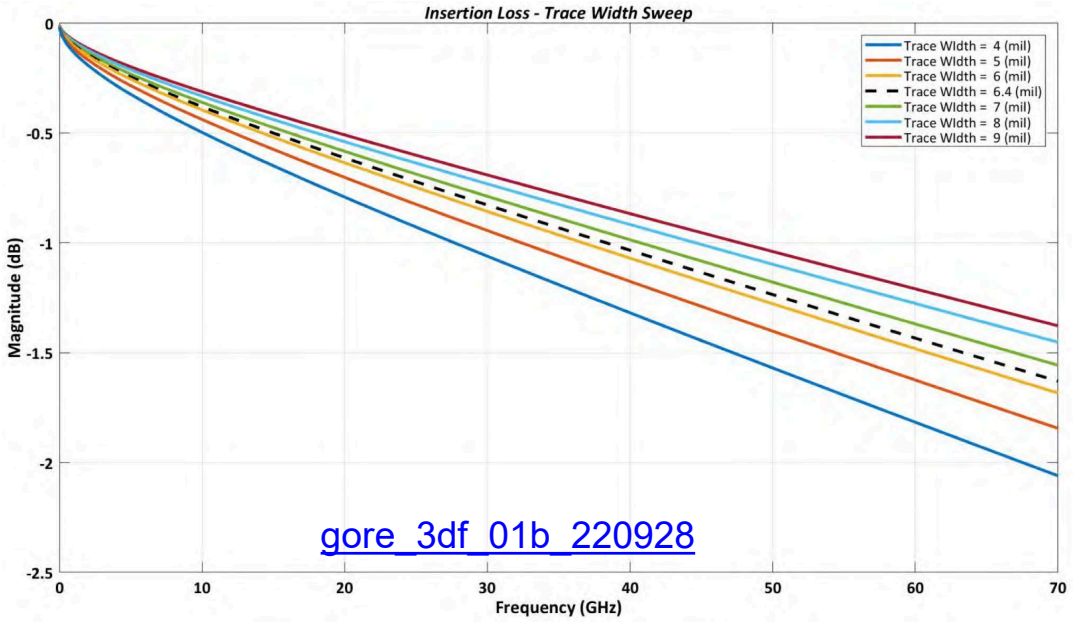


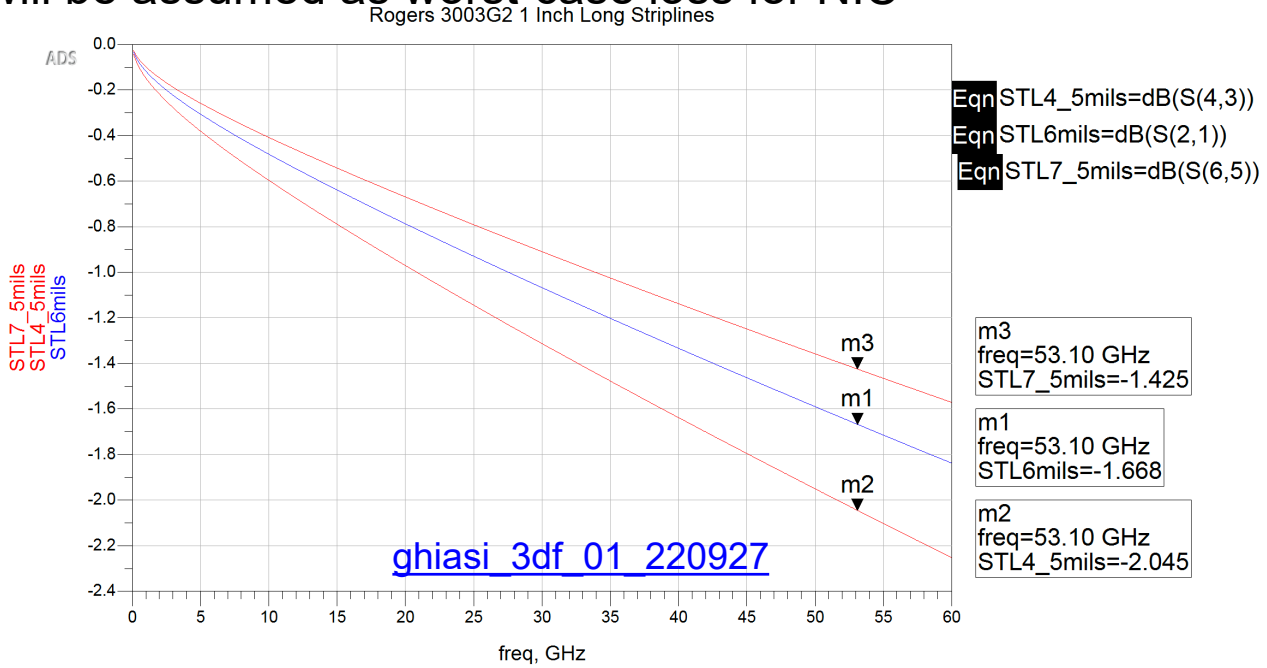
*BGA footprint included in the channel
**Module Loss is 3.5dB @ 53.125 GHz

***Connector loss is 2.2dB @53.125GHz
****PCB Loss is Max 7dB @53.125GHz (93 ohms)
*****Vias are staggered microVia
*****Assumed 1 FEXT and 2 NEXT aggressors

PCB Loss at 53 GHz

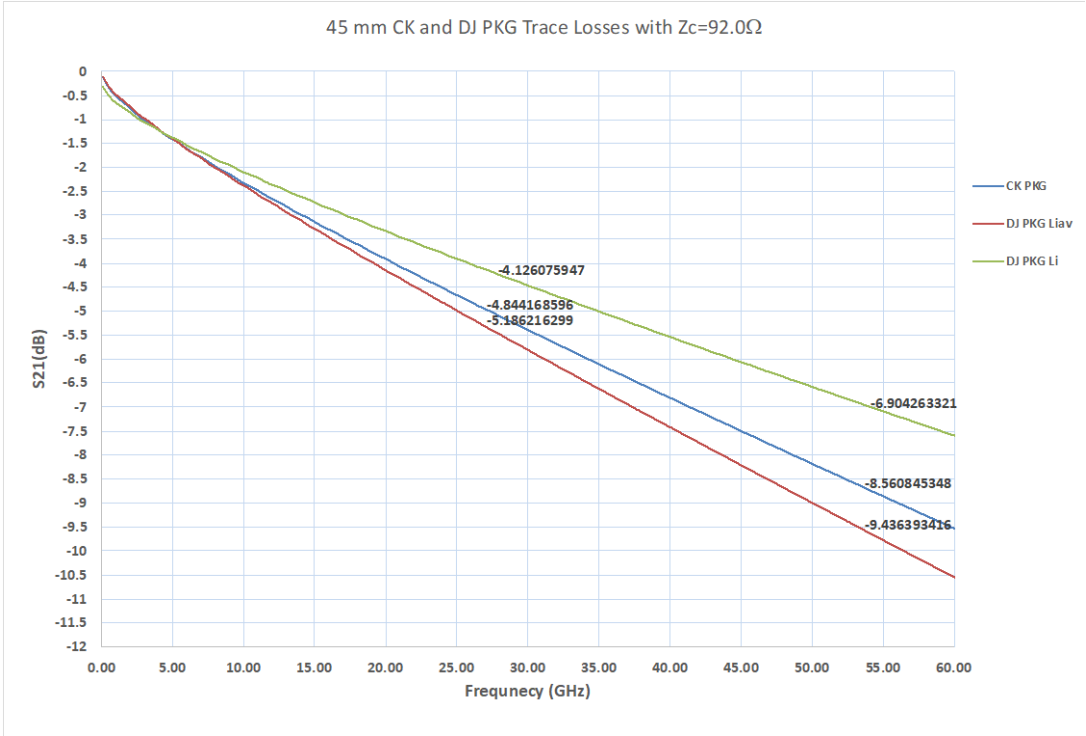
- **Loss of advance next generation PCBs**
  - gore_3df_01b_220928 measured result for 5 mils stripline on next Gen advance PCB material loss estimated at 70 ºC expected to be ~1.52 dB/in
  - ghiasi_3df_01_220927 simulated 6 mils stripline on Rogers 3003G2 at 70 ºC 1.67 dB
  - akinwale_3df_01_20220502 NIC loss for 4.6 mils wide trace is 1.7 dB/in or ~1.6 dB/in at room temperature based on Gore results, 1.8 dB/in will be assumed as worst-case loss for NIC





Comparisons of CK vs Proposed DJ Package Losses

- **What should be our assumption regarding 200G high radix 512 lanes package loss?**
  - Trace length assumed 45 mm
  - li_3df_02_2211 proposes to use skip ABF layers to allow using wider traces to lower loss/mm to ~0.153 dB/mm @53 GHz
  - benartsi_3df_01a_2211 best ABF conventional 27-45-27 µm spacing for 15 µm thick reports trace loss of 0.21 dB/mm @53 GHz at high temperature
  - ghiasi_3df_01_220927 states that with availability of thicker ABF film one may construct wider 38x15 µm traces that still can be routed if one uses 9-2-9 package on high radix switches without using skip layer with estimated loss of 0.189 dB/mm at 90 ºC
    - Lowering package loss further as suggested by Li require traces wider than 50 µm which are not suitable for high density switch break-out.

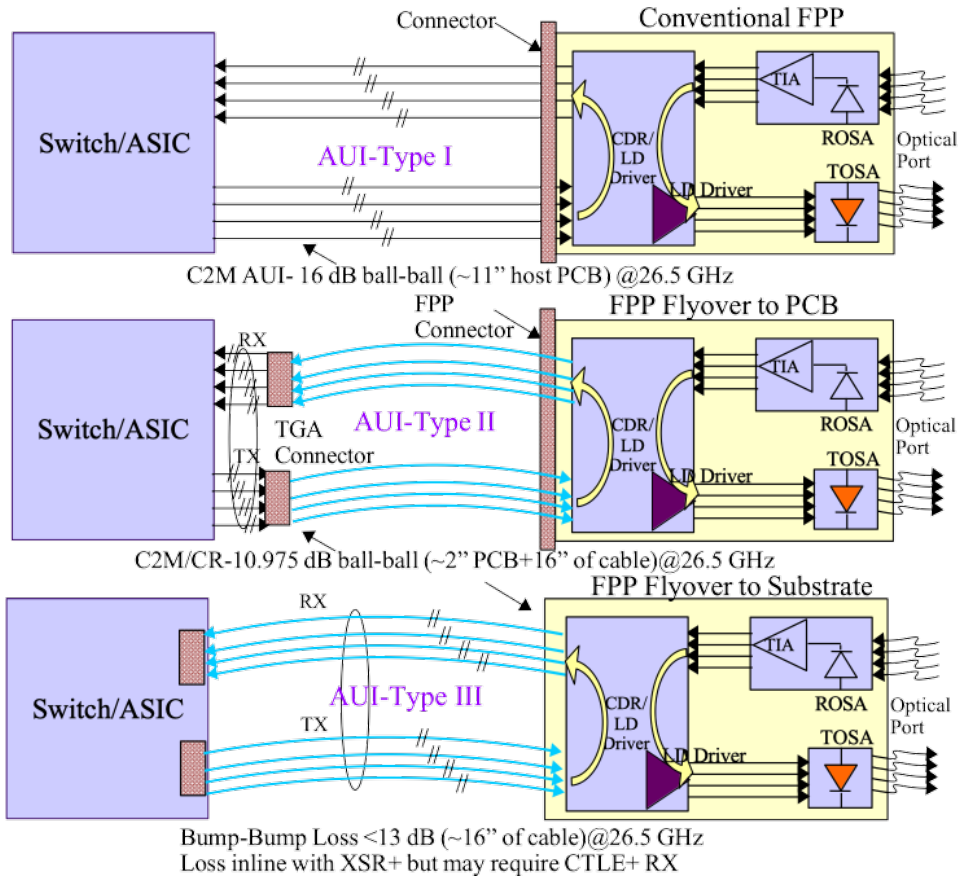


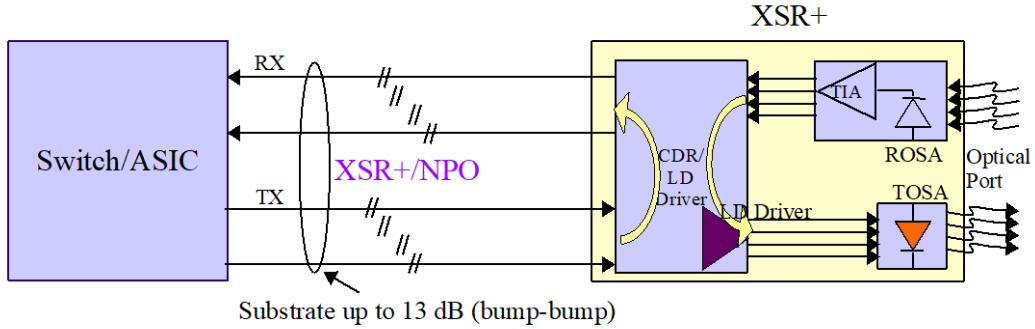
Other Key Loss Components of the Channel

- **Cabled host loss is ~0.35 dB/in @ 53 GHz**
  - kocsis_b400g_01a_210826
- **Host via loss**
  - rabinovich_3df_elec_01b_220921 loss is ~1.25 dB @53 GHz
  - Based on updated rabinovich_3dj_01_230116 analysis max via loss is ~0.8 dB@53 GHz
  - Brandon Gore simulation data support worst case loss of ~0.8 dB @ 53 GHz
- **OSFP connector loss is ~1.6 dB @53 GHz**
  - rabinovich_3df_elec_01b_220921
- **Socket loss is ~0.2 dB @53 GHz.**

Example AUI Interfaces (design types)

- **With in the scope of 802.3dj we have potentially up to 4 AUI classes and as few as 2 classes.**





100G C2M/XSR+ Ecosystem

- **Following interfaces have been defined based on 100 Gb/s PAM4 in the OIF and IEEE:**
  - OIF 112G-VSR/802.3ck CL120G addressing C2M with 16 dB loss
  - 802.3ck CL162 defines CR/C2M with 10.975 dB host loss to support 2 m of passive Cu cable
  - OIF 112G-XSR+ defines NPO/CPC (co-packaged Cu) on HDI board with bump-bump loss of 13 dB.

53 GBd (26.55 GHz) AUIs	**VSR/C2M**	**CR/C2M**	**XSR+**
TP0-TP1a Loss (dB)*	**16**	**10.975**	~7
PCB/Substrate Loss (dB)	11.9	6.875	~7*
Bump-TP1a Loss (dB)	20	14.975	~11**
Bump-Bump Loss (dB)	~22	~16.975**	**13**
Loss Adv PCB(C2M) or HDI(NPO) dB/in	~1.1	~1.1	~1.8
PCB/HDI Length Supported (in)	~10.8	~6.25	~3.8
*Assume 1st level package loss 4 dB. ** PMA package loss assumed 2 dB.			

Potential 200G AUIs Ecosystem

- **Starting point for 200G AUIs/C2Ms:**
  - AUI Type I supporting 11” conventional PCB
    - TP0-TP1a loss increased from 16 dB@100G to ~22 dB
    - Bump-bump loss ~35 dB
  - AUI Type II cabled host
    - TP0-TP1a loss 13.0 dB
    - Bump-bump loss ~26.0 dB
  - AUI conventional NIC supporting 5” PCB
    - TP0-TP1a loss 14 dB
    - Bump-bump loss ~22 dB
  - AUI Type III cabled substrate (CPC)
    - TP0-TP1a loss ~13 dB
    - Bump-bump loss ~26 dB
  - AUI Type V NPO
    - Bump-TP1a loss ~15.5 dB
    - Bump-bump loss ~18 dB.

Loss Parameters @ 53 GHz A. Ghiasi - Rev 1.1 1/10/2023	Loss	Length or #	AUI Type I Conventional PCB	AUI Type II Cabled Host	AUI NIC Conventional PCB	AUI Type III Cabled Substrate	XSR+ NPO
Host PCB Loss (dB/in)	1.5	11	16.5	NA	NA	NA	NA
NIC PCB Loss (dB/in)	1.65	5	NA	NA	8.25	NA	NA
Cabled Host PCB Loss (dB/in)	1.5	2	NA	3	NA	NA	NA
Cable Loss (dB/in)	0.3	12	NA	3.6	NA	3.6	NA
Plug Board/PIC/HCB Loss (dB/in)	1.5	1.7	2.55	2.55	2.55	2.55	2.55
AUI Connector Loss (dB)	1.65	1	1.65	1.65	1.65	1.65	NA
Host Via Loss (dB)	0.8	2	1.6	1.6	NA	NA	NA
NIC Via Loss (dB)	0.6	2	NA	NA	1.2	NA	NA
Host Package Loss (dB/mm)	0.21	45					
NIC Package Loss (dB/mm)	0.225	16					
CDR Package Loss (dB/mm)	0.225	10					
Host/NIC PKG Mode Con. Loss (dB)	1	NA	10.45	10.45	4.6	10.45	10.45
CDR PKG Mode Con. Loss (dB)	0.4	NA	2.65	2.65	2.65	2.65	NA
TGA Connector Loss (dB)	0.3	NA	NA	0.3	NA	NA	NA
Socket Loss (dB)	0.2	NA	NA	NA	NA	0.2	0.2
NPO Substrate Loss (dB/mm)	0.095	50					
NPO Substrate Loss (dB)	4.75	NA	NA	NA	NA	4.75	4.75
TP0-TP1a Loss (dB)	NA	NA	22.3	12.7	13.65	12.75	4.95
Bump-TP1a (dB)	NA	NA	32.75	23.15	18.25	23.2	15.4
Bump-Bump Loss (dB)	NA	NA	35.4	25.8	20.9	25.85	17.95

Summary

- **To support 512 lane switches package trace length need to be 45 mm long**
  - benartsi_3df_01a_2211 0.21 dB/mm is a reasonable package loss for dj packages based on next generation ABF film using conventional 27 μm wide construction
  - ghiasi_3df_01_220927 0.189 dB/mm is a more aggressive package loss assuming next generation ABF film and new construction with wider 38 μm traces but narrower than assumed by li_3df_02_2211
- **200G AUI classes can categorized into the following types**
  - High loss AUI with up to 36 dB bump-bump and 23 dB TP0-TP1a losses
  - Medium loss AUI with up to 26 dB bump-bump and 14 dB TP0-TP1a losses
  - Near package AUI/XSR+ with up to 18 dB bump-bump loss.