Automotive Cable Harness and Channel Limit

IEEE 802.3dm

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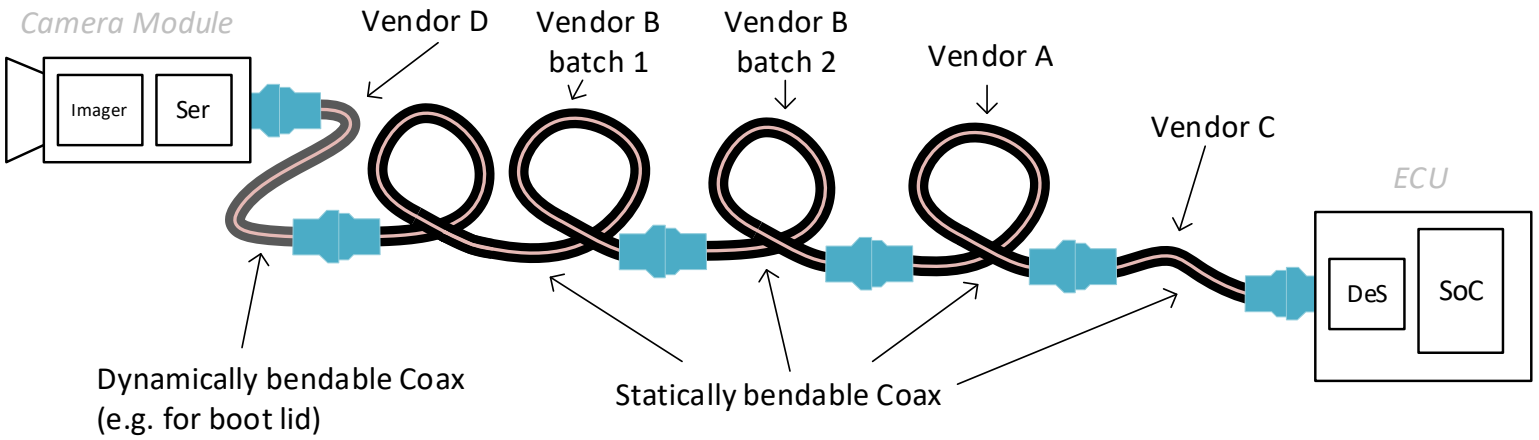
Motivation

- Using realistic data from cable harness as channel limit
- Making sure, an 802.3dm based system will be low cost
  (and will not require a special cable solution in the field)

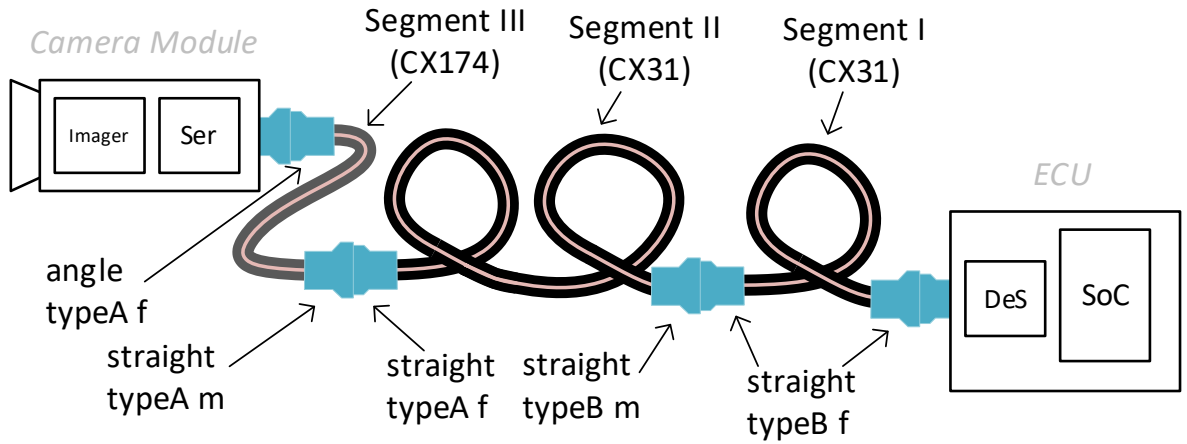
Assembling a Cable Harness



- For this type of application, cable harness maker sources segments in batches
  - Different (coax) cables types, different vendors with different products
- Worker takes one from the batch of a certain cable harness segment and installs it
- Even same vendor, same cable type neighboring segments in a harness are not on the same cable spool, and certainly not from one continuous segment on the spool

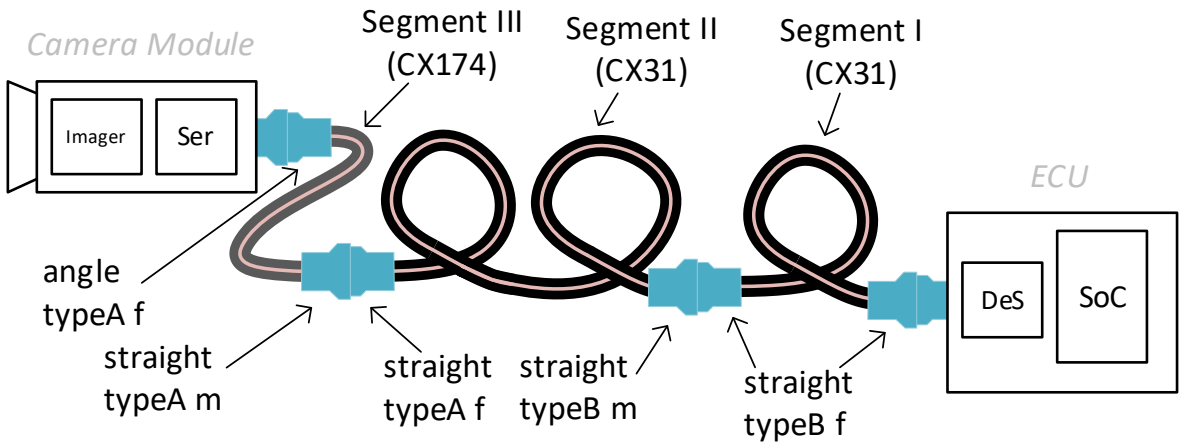
→ Assembled cable harness is a combination of harness segments with random electrical parameters (within the range of the respective data sheet)

Assembling a Cable Harness (Example)



- 4 companies involved
- Connector maker(s) deliver(s) to assembly maker
  - 5 different connector products
- Cable maker(s) deliver(s) to assembly maker
  - 2 different cable products … spools of 100m each
- Assembly maker runs 3 stations … one for each segment
  - Each stations has different tooling for different connector types
  - Cutting cable, removing isolation, crimping, connecting cable shield, sliding on housing
- Assembly maker ships batches of Segment I, Segment II and Segment III to cable harness maker

Assembling a Cable Harness (Example)



Segment	I	II	III
Length	5.5m	8.5m	1m
Cable Type	CX31	CX31	CX174
Spool change every ... units	18	11	100
Spools used	**550**	**900**	**99**

- Example: 9900 cable harness units have to get made with that 3 segments coax cable link
- Within those 9900 cable harnesses, there are **1430 different spool combinations at minimum**
  - 900 different spools for Segment II alone, spool changes do not align between segments
  - 1430 is true, if the harness maker gets all segments from the 3 stations at the assembly maker and uses them strictly in the assembly maker fabricated sequence units
  - In reality, the number of spool combinations will be higher … because fabricated units are NOT numbered … and harness maker will run several stations in parallel

Assembling a Cable Harness

- Bulk deliveries from connector maker, cable maker will max out data sheet / specification limits
- Simple economics: minimizing cost (maximizing profit) means minimizing production time and maximizing the accepted parts / yield
- Especially for standardized products like CX174, CX31 … different vendors are used

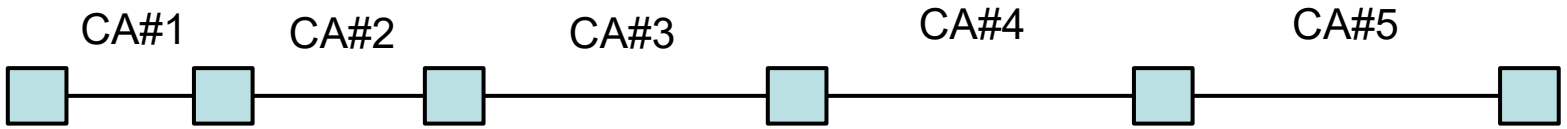
- In the supply chain of connector and cable maker to assembly maker to harness maker … even for a relatively small number of harnesses, many combinations of cable and connector batches will show up for the same 3 segment coax link … all specification value extremes will combine

Previous Presentations

- Detailed analyses of Return Loss of cable harness
  - https://ieee802.org/3/dm/public/0924/bergner_3dm_01a_18_09_24.pdf
  - https://ieee802.org/3/dm/public/0724/Zerna_802.3dm_01b_240717_IL_RL_Limits.pdf
  - https://ieee802.org/3/dm/public/0724/mueller_3dm_01a_07_01_24.pdf

From cable to harness

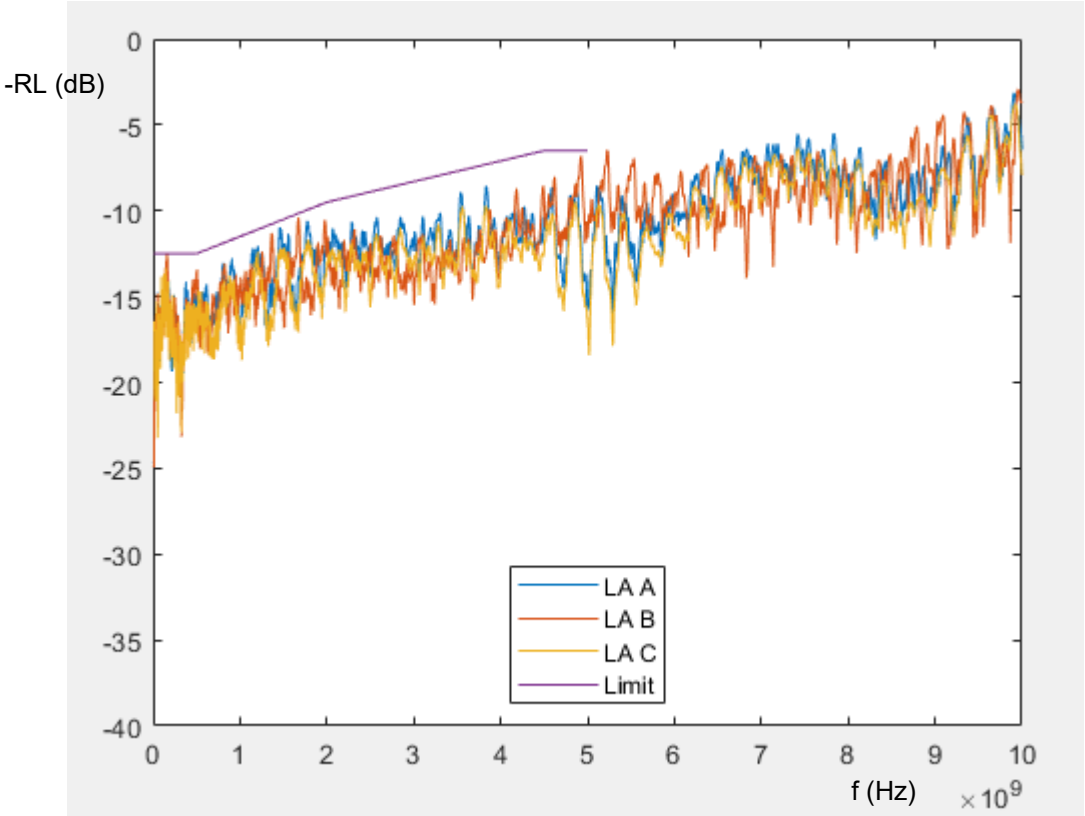
- Example for Coax – with connectors:



Topology variations, realistic connector model (no worst-case):

LA RL worst case (A)	CA#1	CA#2	CA#3	CA#4	CA#5
cable	CX174	CX174	CX31	CX31	CX31
length	0.3m	0.36m	1.0m	11.84m	1.5m
LA RL worst case (B)	CA#1	CA#2	CA#3	CA#4	CA#5
cable	CX31	CX31	CX31	CX31	CX174
length	0.3m	0.36m	1.0m	11.84m	1.5m
LA RL worst case (C)	CA#1	CA#2	CA#3	CA#4	CA#5
cable	CX174	CX174	CX31	CX31	CX31
length	0.3m	0.36m	6.34m	4m	4m

$$RL \geq \begin{pmatrix} 12.5 & 10\ MHz \leq f < 500\ MHz \\ 12.5 - 3\frac{f-500}{1500} & 500\ MHz \leq f < 2000\ MHz \\ 9.5 - 3\frac{f-2000}{2500} & 2000\ MHz \leq f < 4500\ MHz \\ 6.5 & 4500\ MHz \leq f \leq 5000\ MHz \end{pmatrix} \text{dB}$$



Summary

- If 802.3dm wants to support a cable harness made from standard components, the full variation of parameters of these components has to be the basis of the channel limit
  - Anything else means, working off non-standard components with tighter limits and higher cost

- Propose to adopt channel/cable RL limit of slide 9

Thank You!