Further Analysis of Link Segment Delay Considerations

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Outline

Based on the contributions and discussions at the May meeting, the intention of this contribution is to provide a more comprehensive analysis of this topic. The analysis includes the following areas:

- ❑ **Review of the history behind the "up to at least 15m" objective in the Study Group phase**
  - ❑ Including a brief review of the significant data and rationale behind this decision
- ❑ **Comments on speculated applications for longer cables**
- ❑ **The use and consistent interpretation of "up to at least xx m" in the rest of IEEE 802.3**
- ❑ **Proposal**

Review of Study Group Cable Length Discussion (1)

- **Reminder of the scope from the approved P802.3 PAR:**
  - "Specify additions to and appropriate modifications of IEEE Std 802.3 to add Physical Layer specifications and management parameters for electrical media and operating conditions optimized for automotive end-node camera links for operation up to 10 Gb/s in one direction and with a lower data rate in the other direction."

- **From the "Need for the Project"**
  - "These end-nodes are highly constrained on complexity and power consumption and converting them to Ethernet will require solutions specified for their operating conditions."

Review of Study Group Cable Length Discussion (2)

- **Key contributions**
  - https://www.ieee802.org/3/ISAAC/public/082823/zimmerman_3ISAAC_01a_082923.pdf proposes "supporting up to four inline connectors for at least 11m on both automotive coax and shielded balanced pair media"
  - https://www.ieee802.org/3/ISAAC/public/102523/jonsson_3ISAAC_01_102523.pdf proposed a limit of "at least 11m" based on the conclusions of 802.3cy. It concluded that "the 15m reach is probably more than what is needed."

Review of Study Group Cable Length Discussion (3)

- **Key contributions (continued)**
  - https://www.ieee802.org/3/ISAAC/public/1123/matheus_ISAAC_03_1411202327_v1.0b.pdf provided extensive market analysis related to the passenger car market and the cable lengths required by different types of cars. To summarize its conclusions based on this data:
    - 5m is adequate for 75% of cars
    - 12m would cover large cars
    - It recommended choosing 15m to provide "a safety margin (e.g. 30%)"
      - During discussion, it was clarified that 15m would also cover larger vehicles like utility vans and pickup trucks
  - https://www.ieee802.org/3/ISAAC/public/1123/matheus_jonsson_dalmia_ISAAC_01_1411202327_v1.0.pdf recommended adopting the 15m objective.
    - Associated motion passed

Review of Study Group Cable Length Discussion (4)

- **Notes about the speculation “What if 30m’s of cable is desired?” that mentioned buses and trucks during the discussion:**
  - There are typical city and regional buses as well as non-trailer trucks that are around 10.7m-12.2m long.
  - The market share as such for these long vehicles is small.
  - The share of cameras in these vehicles, where the 15m limit cannot be achieved with a reasonable ECU placement, can be expected to be even smaller.
  - Zonalization is a futureproof approach for enabling reasonable ECU placement.
  - Furthermore, the cost structure of such vehicles is different, and they fall out of the target market of this project.
  - While utility vans might have a somewhat larger market than long busses and trucks, they are shorter.

Review of Study Group Cable Length Discussion (5)

- **Key Takeaways:**
  - The project PAR clearly reflects the discussion and decisions that project scope is optimized support for automotive end-node camera links
  - The choice of 15m as the length target was based on significant actual data and discussion

- **P802.3dm should not consider deviating from this agreement and objective based on speculations. It should not be revisited without:**
  - A clearly defined use case,
  - Compelling market data to justify addressing the use case, and
  - Adequate technical analysis to demonstrate that longer cable lengths would have no undesirable system implications

Review of IEEE 802.3 terminology and interpretation

- **The following clauses include the "up to at least **m" or "up to **m" statements with a maximum delay specification:**
  - cable delay = $10^9 / nc = 10 / 3n = 3.33/n$ ns/m, where n is the cable velocity factor

Clause	Objective	Delay limit	Calculated delay per objective	Comment
97 Type A	Up to at least 15m	shall not exceed 94 (UTP)	D = (15*3.33)/0.532 = 94 ns	Limit = Calculated value
97 Type B	Up to at least 40m	shall not exceed 234 (STP)	D = (40*3.33)/0.532 = 251 ns	Limit < Calc. value
113	Up to 30m	185 ns	D = (30*3.33)/0.541 = 185 ns	Limit = Calculated value
126	Up to 100m	570 ns	D = (100*3.33)/0.585 = 570 ns	Limit = Calculated value
149	Up to at least 15m	shall not exceed 94 ns (SBP)	D = (15*3.33)/0.532 = 94 ns	Limit = Calculated value
165	Up to at least 11m	shall not exceed 60 ns (SBP)	D = (11*3.33)/0.611 = 60 ns	Limit = Calculated value

  - IEEE 802.3 consistently uses the "up to at least" value as the basis for the delay limit with no added margin
    - Makes no distinction between "up to" and "up to at least"

Review of IEEE 802.3 terminology and interpretation

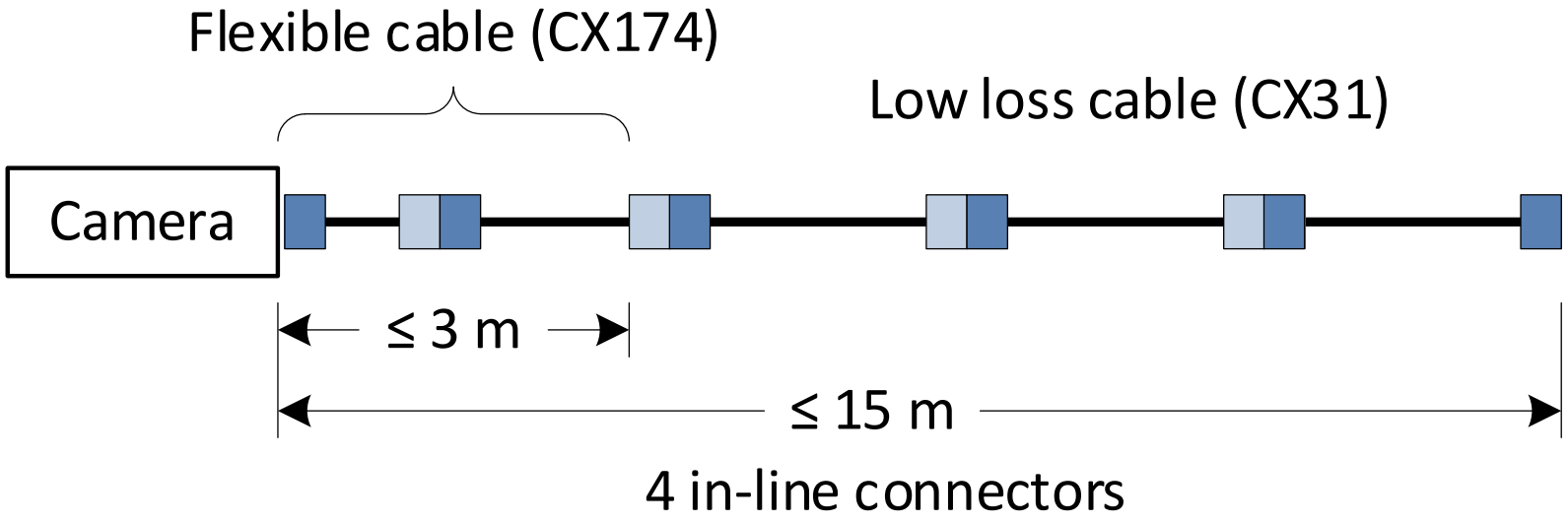
- **Key Takeaway:**
  - IEEE 802.3 consistently uses the “up to at least” value as the basis for the delay limit with no added margin
  - IEEE 802.3 makes no distinction between “up to” and “up to at least” with respect to delay limit specification

- **Consequently, for P802.3dm to be consistent with existing IEEE 802.3 text and practices, choosing a delay specification associated with a long cable would require:**
  - Changing the P802.3dm objective to a cable length longer than 15m, or
  - Filing a maintenance request against clauses 97, 149 and 165 to modify their use of the “up to at least” terminology to fit the interpretation that has been proposed for P802.3dm

- **We believe that the clear and consistent answer is to accept 15m as the basis for the P802.3dm coaxial delay limit.**

Link Propagation Delay for –V1

(per https://www.ieee802.org/3/dm/public/0525/gorshe_3dm_01_2505.pdf)



Per the velocity factor assumptions of the previous slide , the worst case is:

- Total Delay = (5.05 × 3) + (5.05 × 12) + (connector delay) ≈ 76 ns

As shown on Slide 9, the maximum delay calculations correspond to just the cable delay, with no additional margin for connectors.

Link Propagation Delay – Conclusions and Proposals

- **In summary:**
  - There was significant data and discussion behind the 15m objective
    - The 15m cable limit can already support the primary cited applications that were speculated to need a longer cable.
  - IEEE 802.3 is 100% consistent in using the value *X* in "up to at least *X* m" when specifying a maximum link segment delay.
    - Hence, choosing a longer reach (e.g., 30m) for the maximum link segment delay should be accompanied by a P802.3dm Objectives change.

- **Proposal: For consistency with the P802.3dm Objectives and IEEE 802.3 terminology usage, 15m should be used as the basis for maximum link segment delay.**
  - It is time to move forward.
  - Per, https://www.ieee802.org/3/dm/public/0525/gorshe_3dm_01_2505.pdf, we recommend the value of no more than 84ns for coaxial cable, which already a compromise in that it adds >7ns of margin to the calculated value for 15m