Single Mode Fibre Loss

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Motivation

Many solutions for 100 Gbit/s Ethernet have proposed to use CWDM to carry the multiple lanes over separate wavelengths on a single fibre.

The presentation from Monterey anslow_01_0107.pdf included a graph of assumed loss vs. wavelength to justify the choice of CWDM channels to be analysed. It was noted during the meeting that this loss vs. wavelength information was very different from the loss vs. wavelength curve built in to the 10G link model spreadsheet v 3.1.16a.

This document looks at the equation used in the link model spreadsheet and compares it to the loss assumptions used by the ITU-T in the development of the CWDM applications Rec. G.695.

Equation in link model spreadsheet

The equation that governs the loss coefficient vs wavelength in the link model spreadsheet is:

$$\text{Loss coeficient} = \frac{R_\lambda}{C_\lambda}\left[\left(\frac{1}{9.4\cdot 10^{-4}\lambda_c}\right)^4 + 1.05\right]$$

Where: R_λ is the actual cable attenuation in dB/km at a specific wavelength (e.g. 850 nm or 1300 nm). For 850 nm C_λ = 3.5dB/km, at 1310 nm C_λ = 1.4846 dB/km.

The multiplier R_λ / C_λ allows the curve to be scaled to pass through the value R_λ at either 850 or 1310 nm

Equation derivation

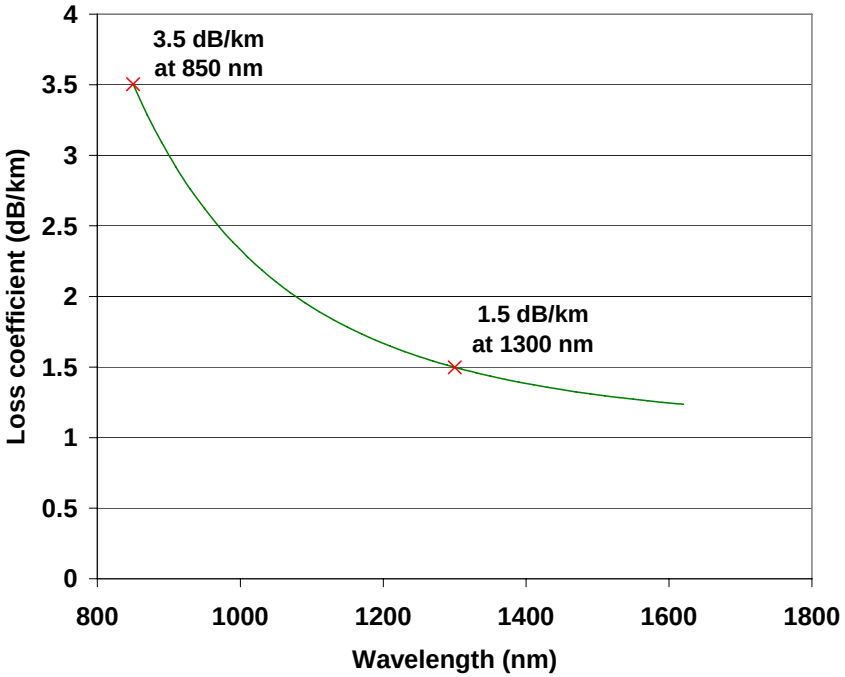
Evaluating the term:

$$\left[\left(\frac{1}{9.4\cdot 10^{-4}\lambda_c}\right)^4 + 1.05\right]$$

Gives the curve on the right and is the equation:

$$\alpha\,(\mathrm{dB/km}) = \frac{A}{\lambda^4} + B \quad [1]$$

Fitted to 3.5 dB/km at 850 nm and 1.5 dB/km at 1300 nm



[1] J.J. REFI, Fiber Optic Cable - A Lightguide, (ABC TeleTraining Inc., 1991)

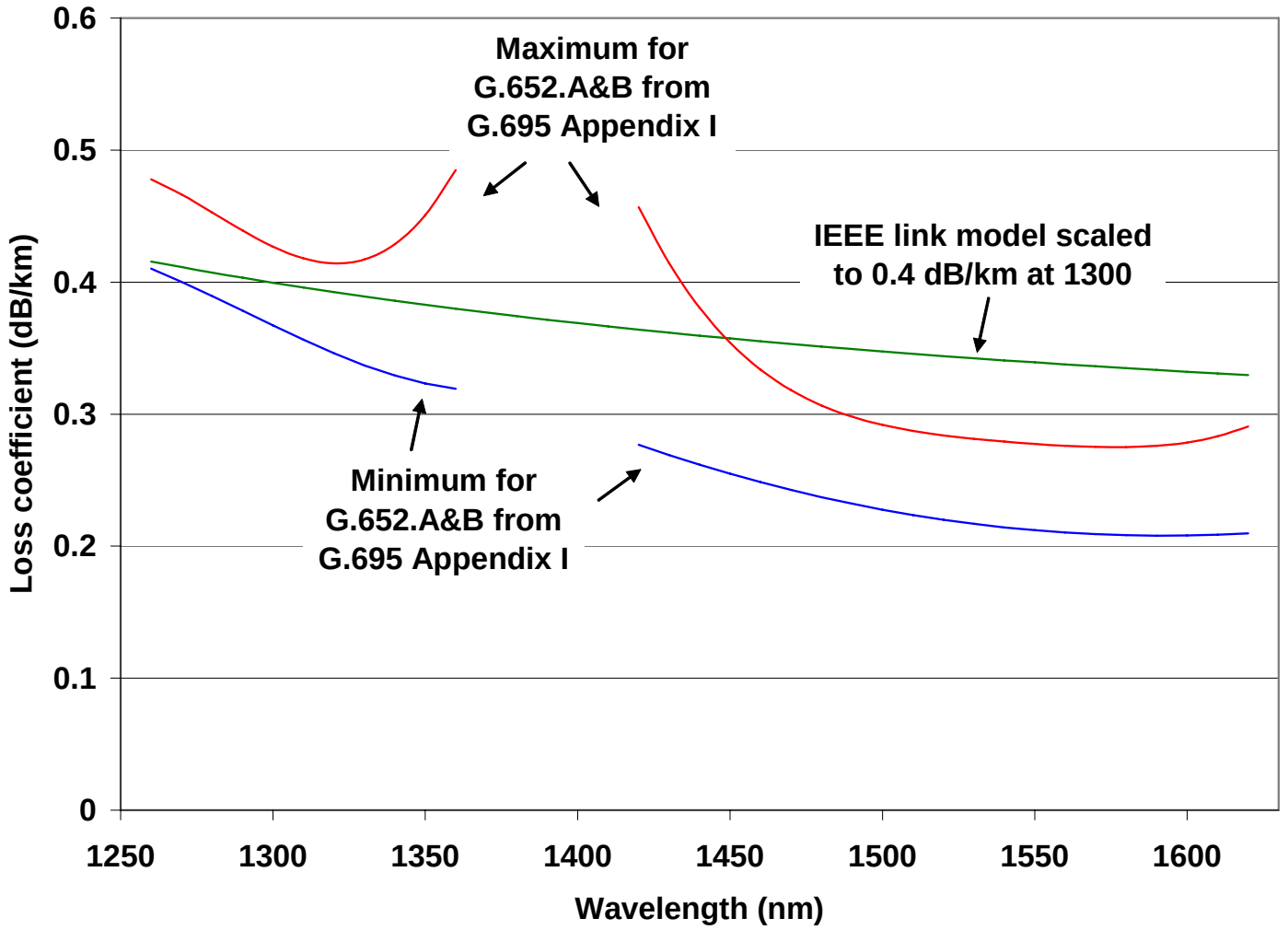
Comparison with G.695 Appendix I

The loss coefficient vs wavelength assumed by ITU-T in the development of the CWDM applications Recommendation G.695 is captured in Appendix I/G.695

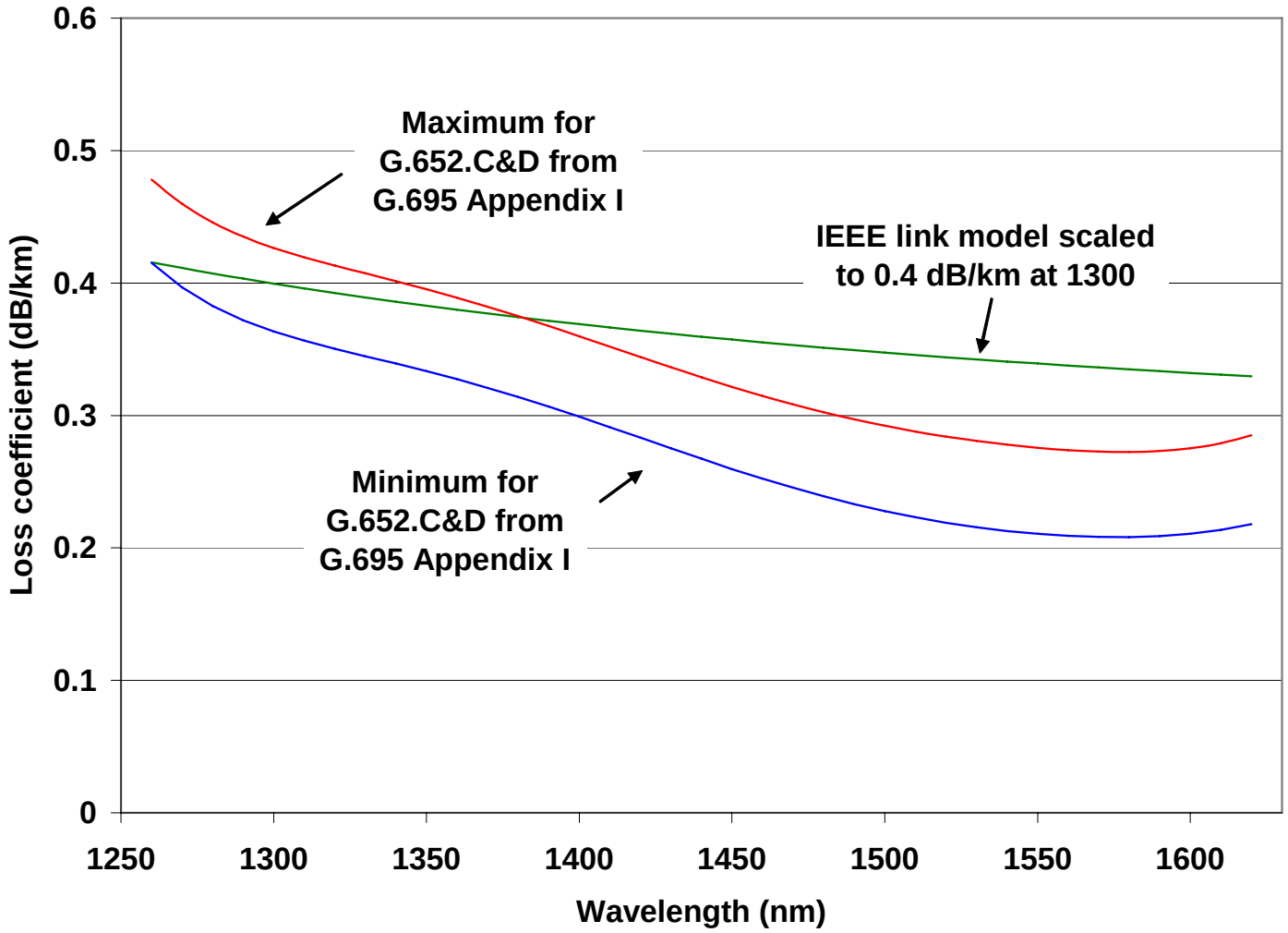
This data is plotted on the next two slides (red curve for the assumed maximum and blue curve for the assumed minimum) together with a green curve which is the equation from the link model spreadsheet normalised to 0.4 dB/km at 1300 nm which is a reasonable figure and is the value assumed by some tabs of the link model spreadsheet.

The next slide is for G.652.A&B standard single mode fibre and the one after is for G.652.C&D low water peak fibre.

Comparison with G.652.A&B data



Comparison with G.652.C&D data



G.695 Appendix I data

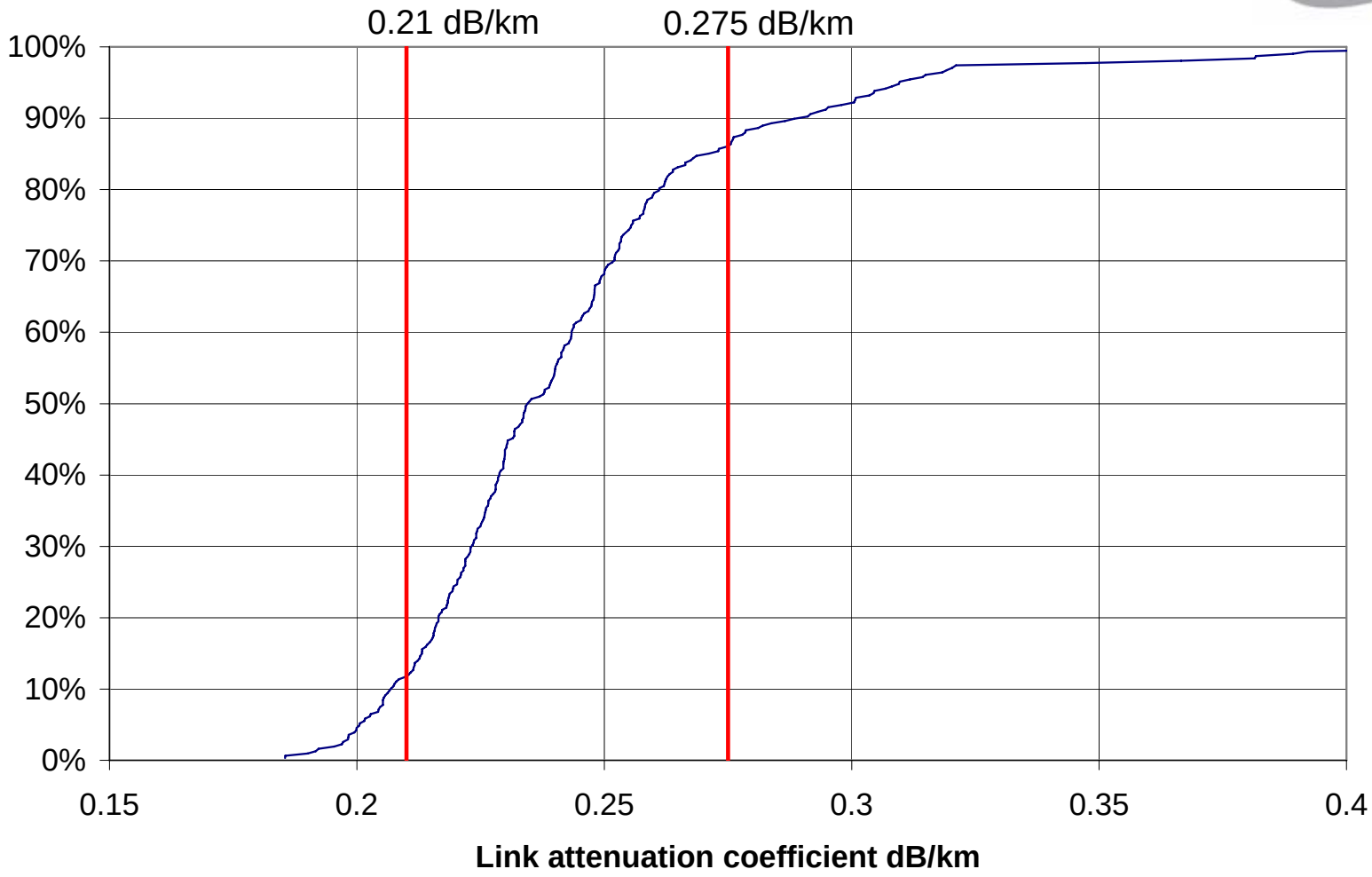
The data captured in Appendix I/G.695 was generated from two sets of data.

The first set was measurements of the difference in loss of G.652 fibre (both older examples with a water peak for G.652.A&B and newer low water peak fibre G.652.C&D) at various wavelengths compared to 1550 nm.

The second was measurements of end-to-end installed link loss at 1550 nm that were made in the period 2003 to 2005 for 309 links from 9 different owners. All of the links in the data set were selected to be > 20 km in length to avoid connector losses at the ends from dominating the loss / unit length results.

The second data set is shown on the next slide together with red lines showing the 0.21 and 0.275 dB/km maximum and minimum values assumed by ITU-T which are at approximately the 10% and 90% points.

End-to-end link loss data at 1550 nm



G. Supplement 39 data

An additional source of loss vs wavelength data can be found in Supplement 39 to the G Series of ITU-T Recommendations Table 10-3.

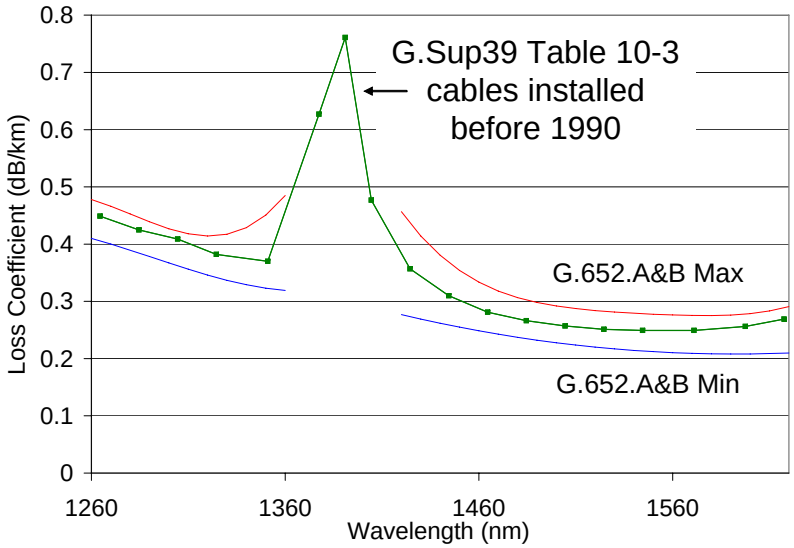
This gives measured loss vs wavelength data from one operator for cables:

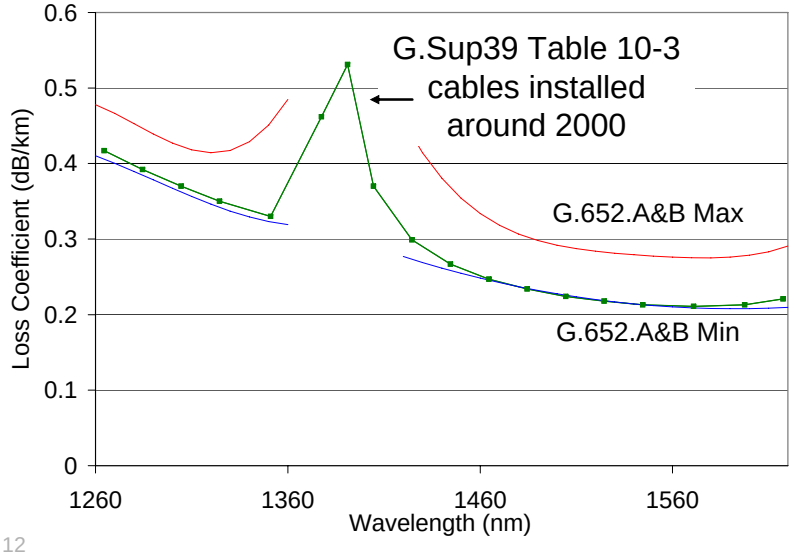
- installed before 1990
- installed around 2000
- installed in 2003

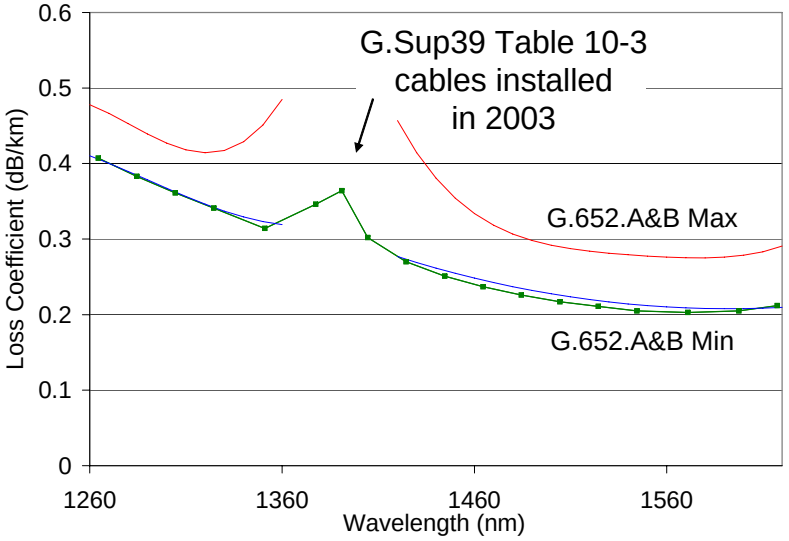
And does **not** include losses of connectors at the ends.

The shape of the curves (especially if shifted upwards to account for additional connector loss), however, agrees very well with the shape of the curves from G.695 Appendix I. See next slide for the average loss curves (in green).

One operator's data vs installed date







Conclusion

Since the loss vs. wavelength curves in Appendix I/G.695 covers G.652 fibre installed from before 1990 and also installed in 2003 and later and since it has been adjusted so that the maximum loss curve covers the measured losses of ~ 90% of recently measured installed end-to-end links, it seems worth capturing these loss values in an updated version of the spreadsheet anslow_02_0107.xls that was presented in Monterey.

Since the equation in the link model spreadsheet predicts a loss of 0.34 dB/km at 1550 nm for a link with 0.4 dB/km at 1300 nm, any attempt to use this equation for CWDM applications seems to be problematic.

Thanks!

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With thanks for input / discussions to:

John Abbott, Corning
David Cunningham, Avago Technologies
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Paul Kolesar, CommScope Enterprise Solutions
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