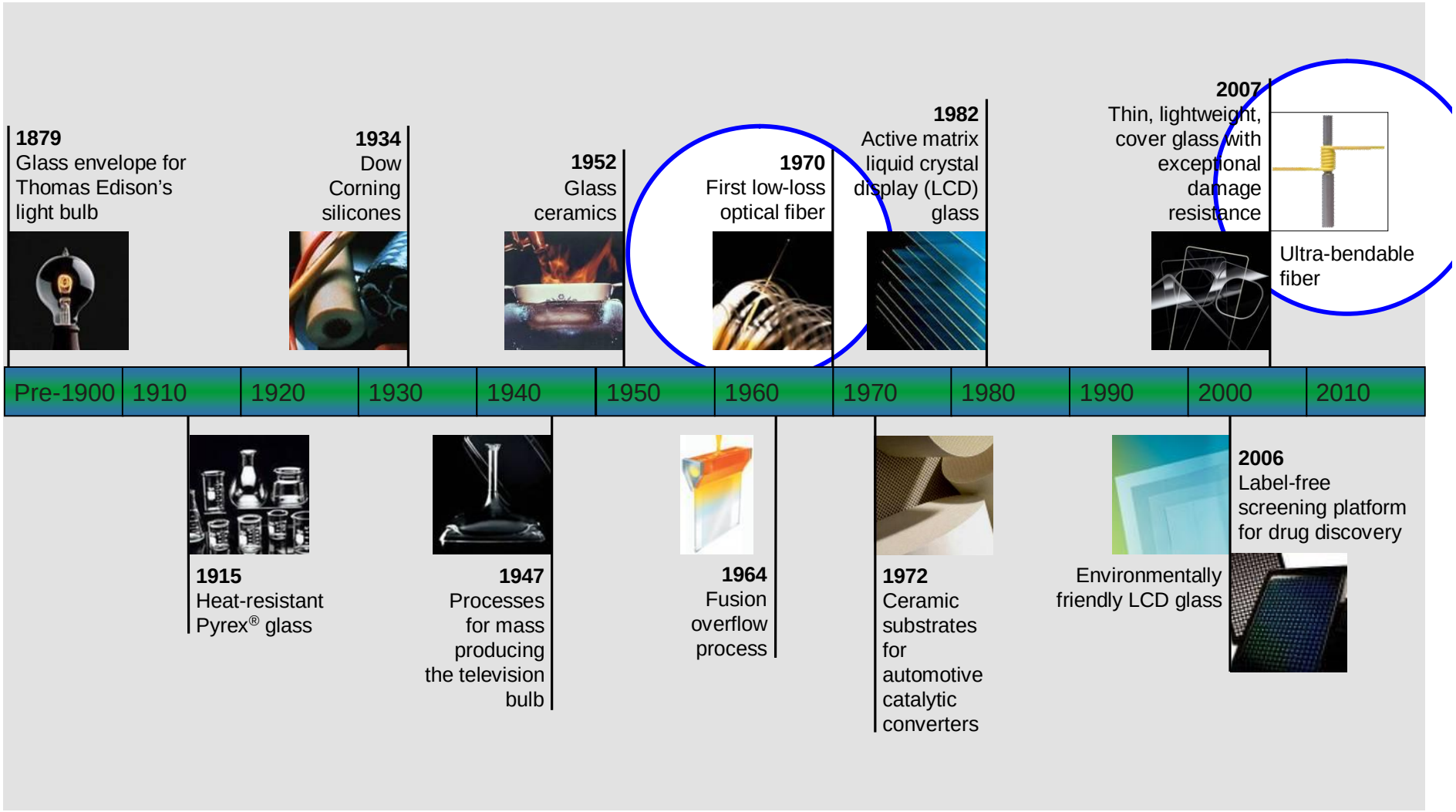
CORNING

Science &
Technology

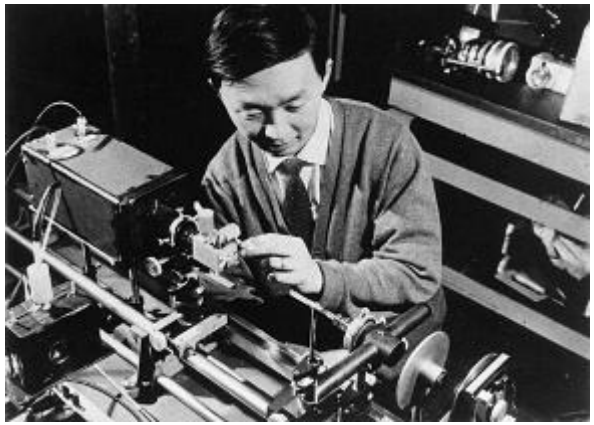
Recherche en verre sur la télécommunication

Dr. Aleksandra Boskovic
Directrice, Corning European Technology Center

A Culture of Innovation

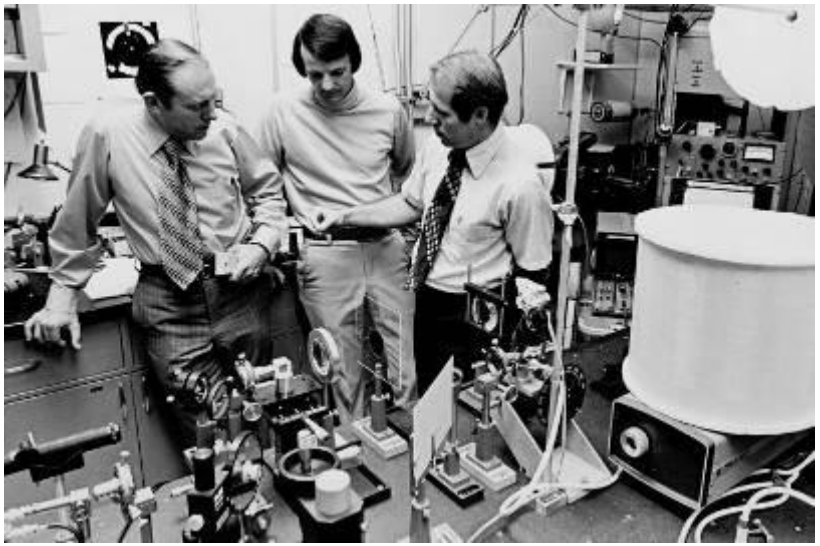


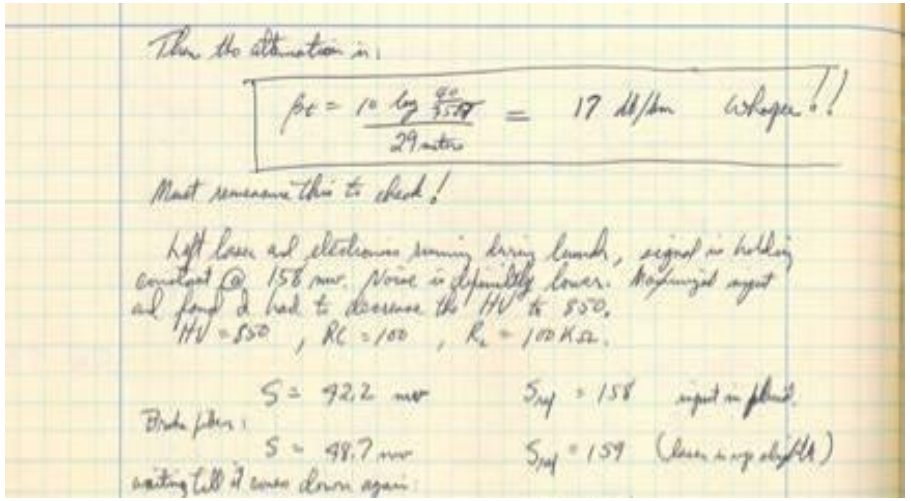
2010 Celebration !



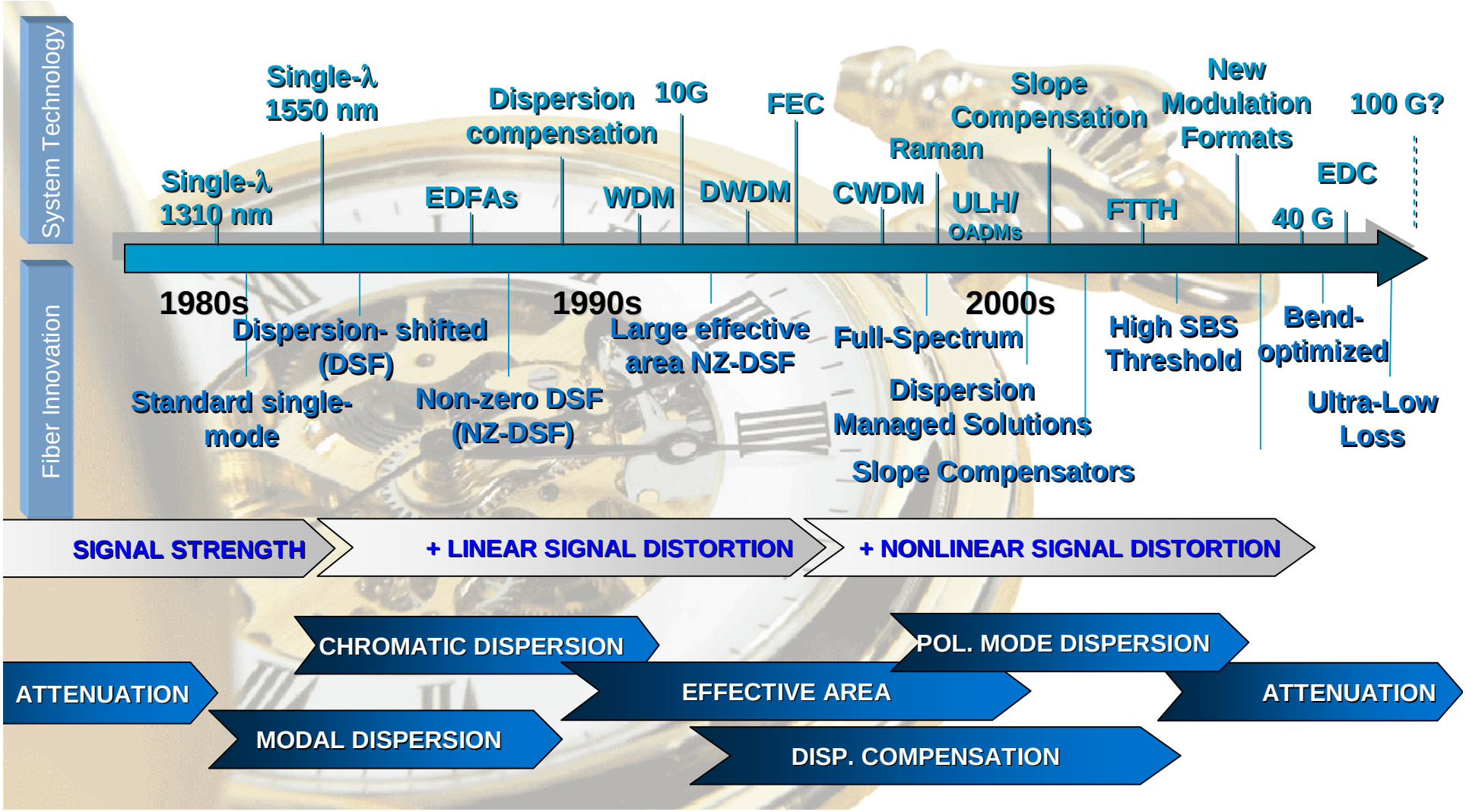
Charles Kao Wins 2009 Nobel Prize for envisioning Optical Fiber and Corning credited for bringing that vision to reality

draw fibers using other types of glass, without much success. Four years after Kao and Hockham's article, a research team from the Corning Glass Works in the United States, with F.P. Kapron, D.B. Keck, P.C. Schultz, F. Zimar, under the leadership of R.D. Maurer, succeeded by a clever chemical method called CVD (Chemical Vapor Deposition) in making glass fibers of fused silica with the low losses that Kao had envisioned. To make a core and a cladding with very close refractive indices, they doped titanium in the fused silica core, and used pure fused silica in the cladding [Appl. Phys. Lett. 17, 423 (1970)]. A few years later, they even reached

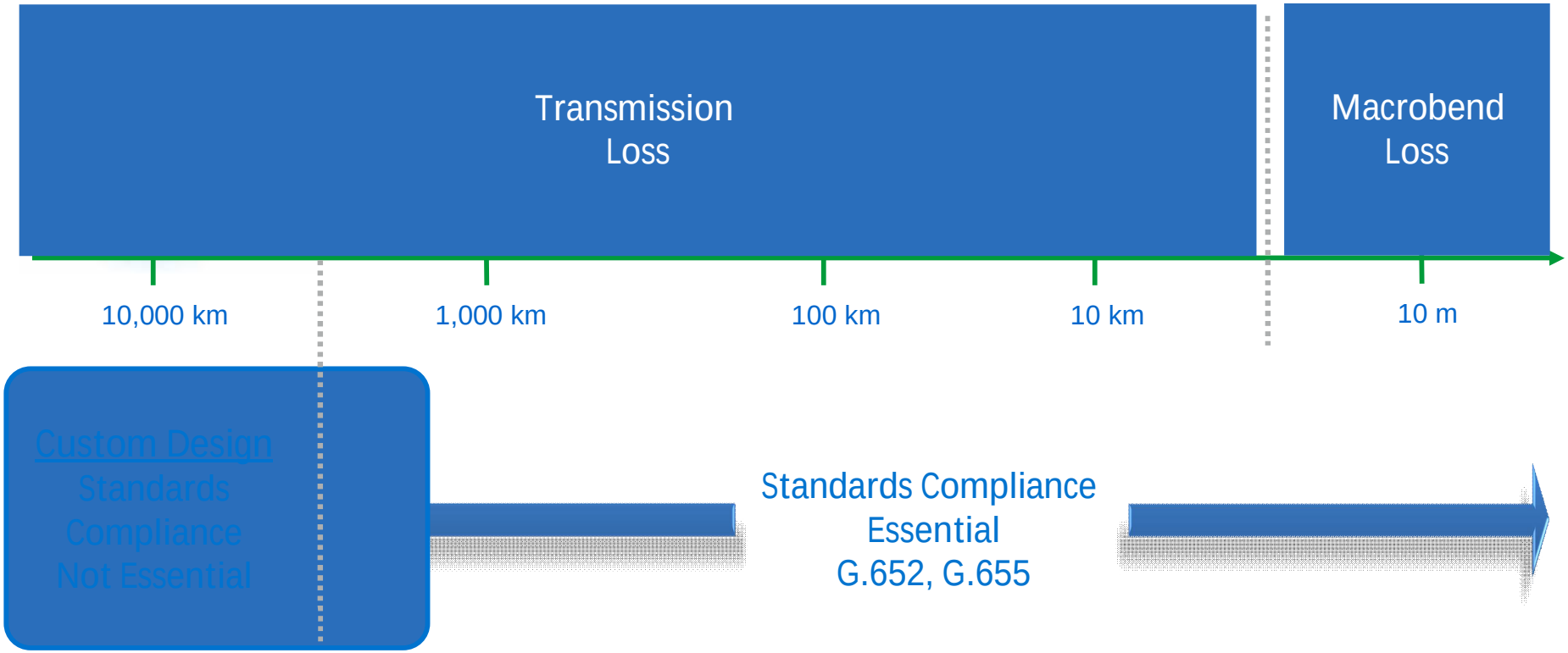




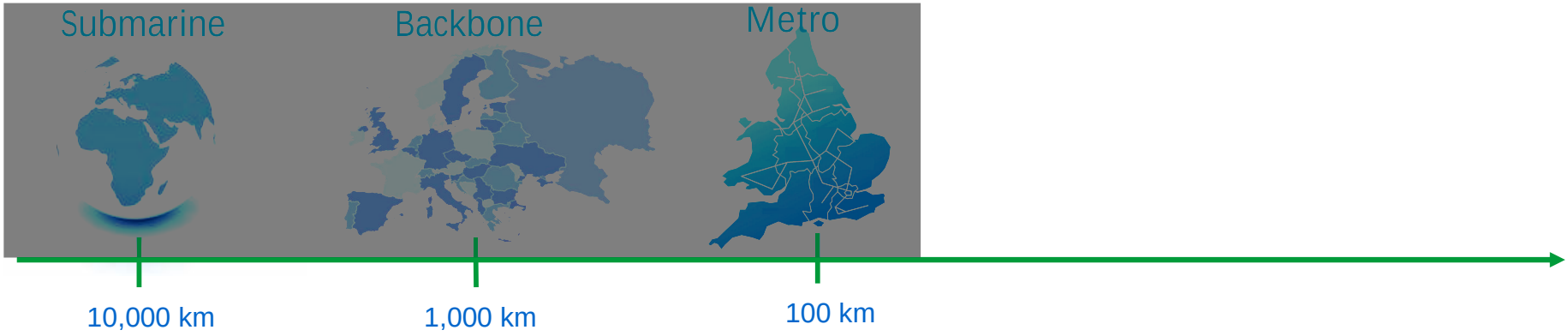
Drivers for Fiber Innovation: System Evolution and New Application Spaces



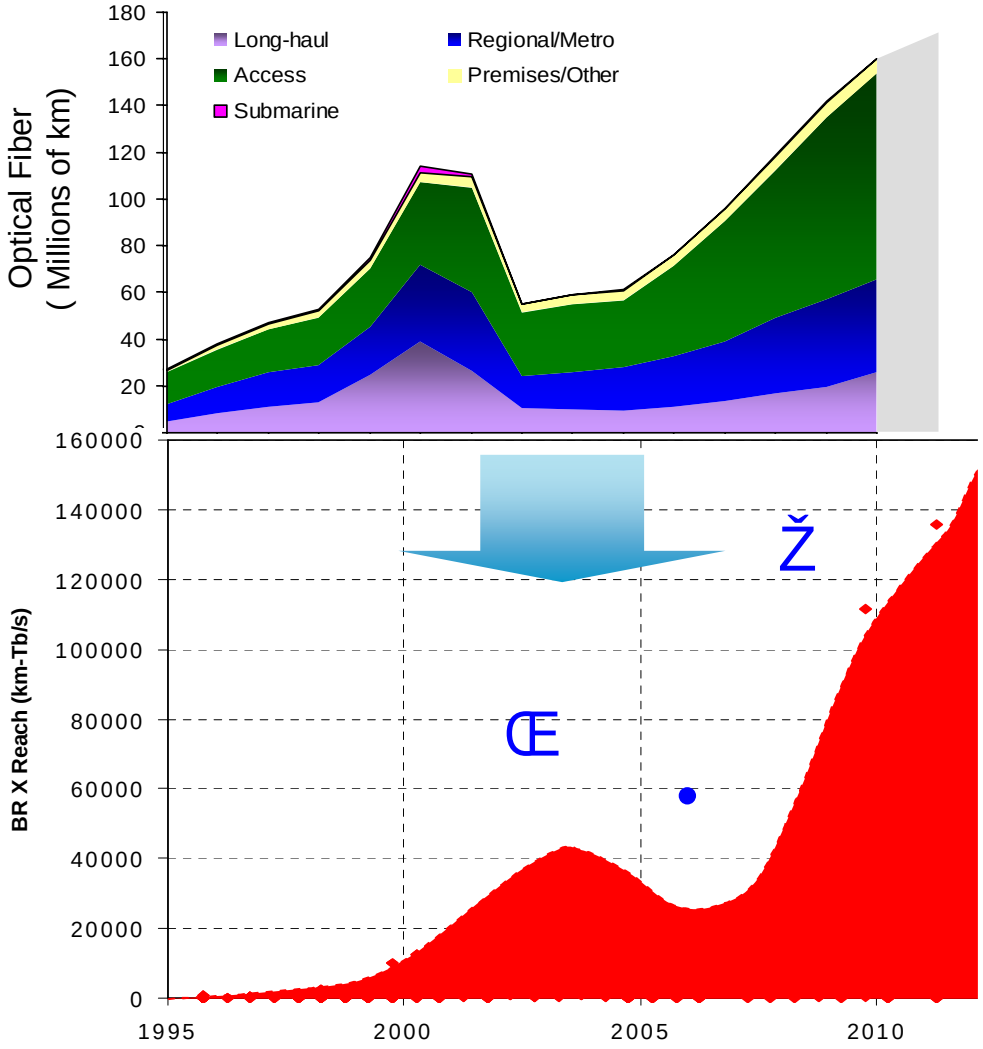
Fiber Innovation
Different Applications = Different Boundaries on Innovation



Innovation on Long Haul and High Data Rate Networks



Optical Fiber: Industry and Performance



- Results of "Bubble" work
  - Focus on Access and Low Cost Systems
- Return to the Capacity Quest !
  - Access driven traffic
  - LH in emerging markets

<u>In addition:</u>

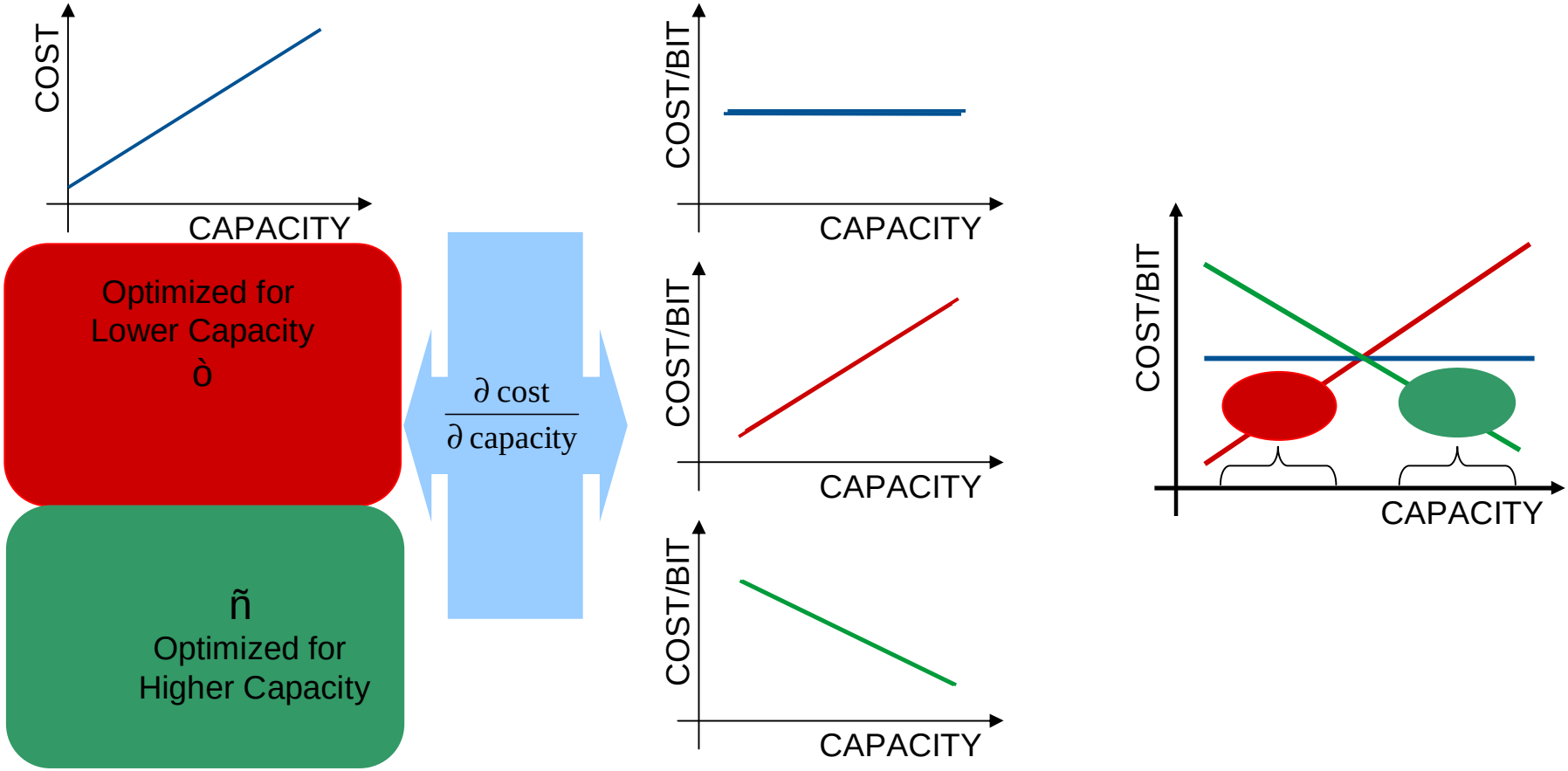
- ≈100 Tb/s in a single fiber achieved in 2011
- 100 Gb/s and coherent systems becoming commercially available

Taking the Risk of “Over Simplification”…

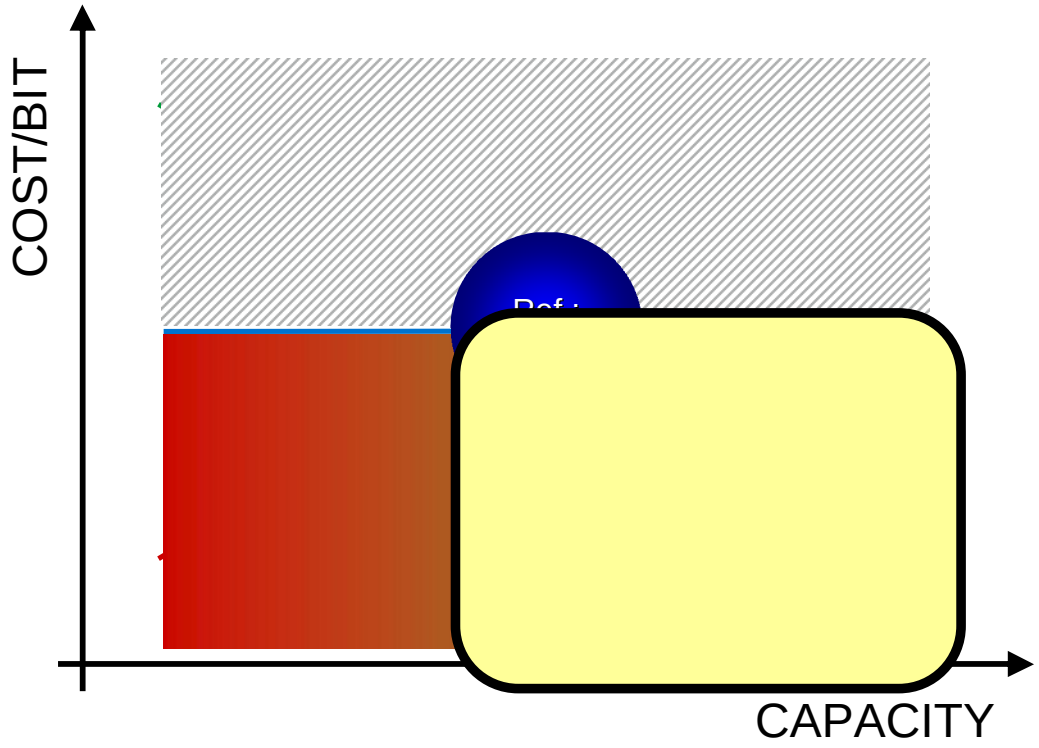
Instead of going through some complex systems update, let’s try to “over simplify” things and focus on actual fiber impact

What is the “Best System”

The more capable or the one that best matches the network requirements ?

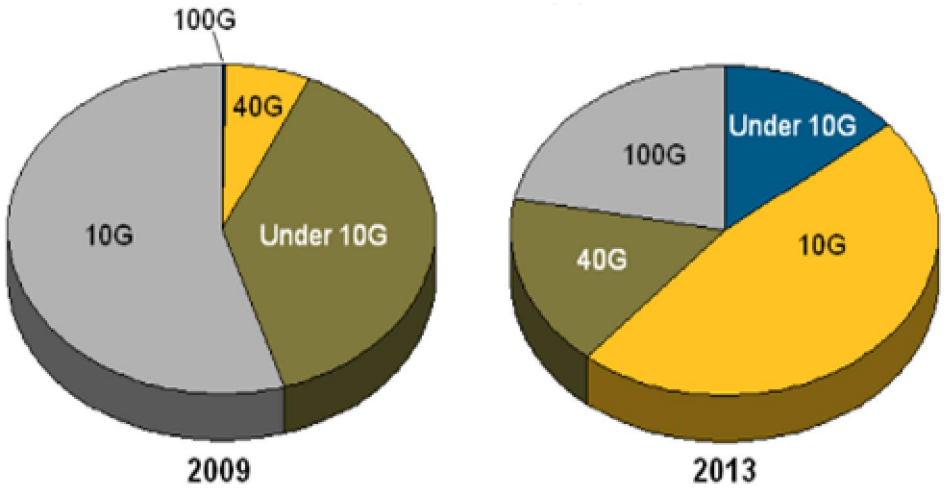


Fiber Impact on Cost/Bit

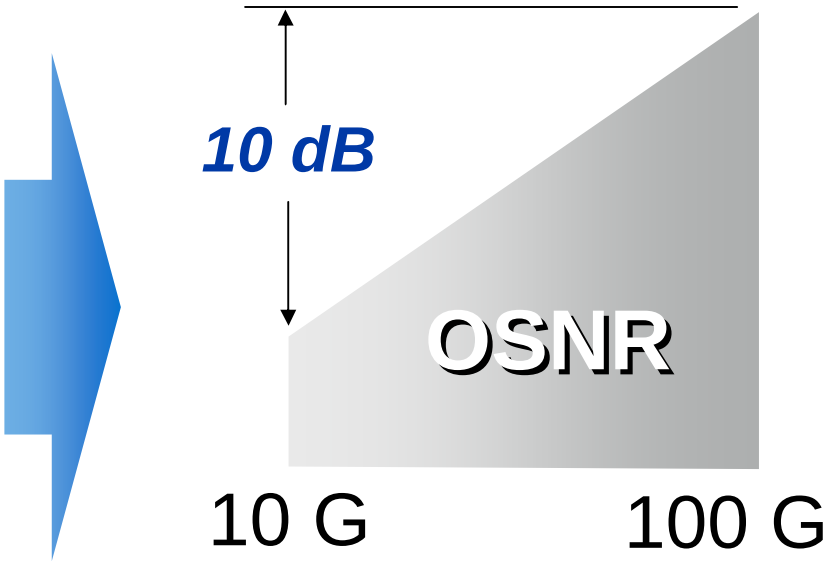


- Reference Configuration
- Reference Fiber
- Not Interested in higher cost options
- How can fiber optimization reduce overall cost ?
- Let's start looking at extreme capacity demand networks

The New Requirements…



Source: Infonetics Research Inc. 2010



1. 100G and beyond
2. Advanced DSP
3. DQPSK and PM-QPSK
4. Coherent Systems
5. But…10G will still be there for a long time…

…And How Advanced Fiber Technology Can Help

$$OSNR_{out} = \frac{\propto A_{eff} / n_2}{P_{ph} \cdot NF \cdot N_{Spans}} \cdot \propto \mathrm{Att.}$$

Fiber Independent

Fiber Effective Area

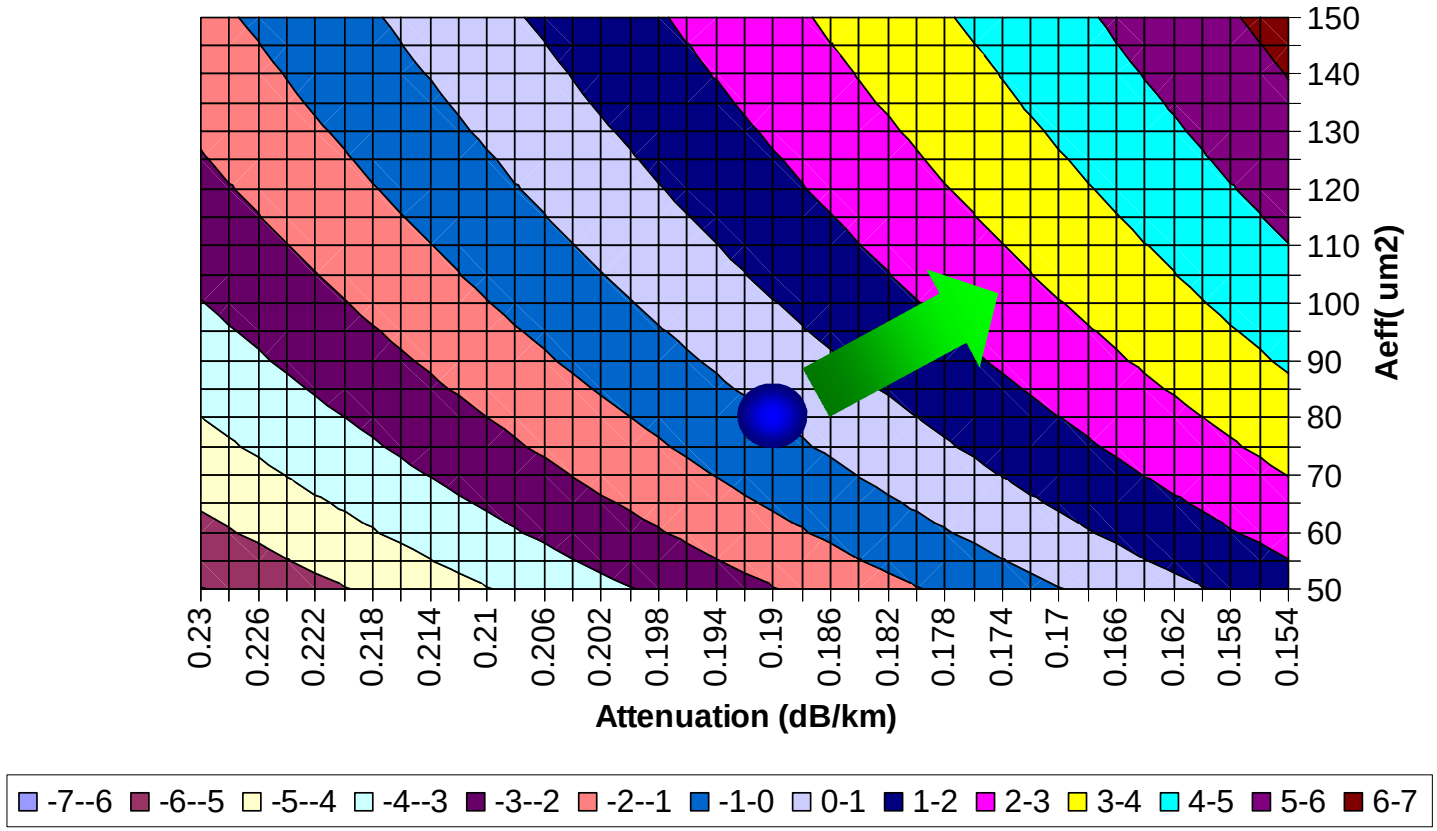
Fiber Attenuation

$$\text{Fiber FOM(dB)} \approx 10\log\left(\frac{A_{eff,F1} \cdot n_{2,F2}}{A_{eff,F2} \cdot n_{2,F1}}\right) - (Att_{F1} - Att_{F2}) \cdot L$$

Bergano, OFC 2009, SubOptic 2010

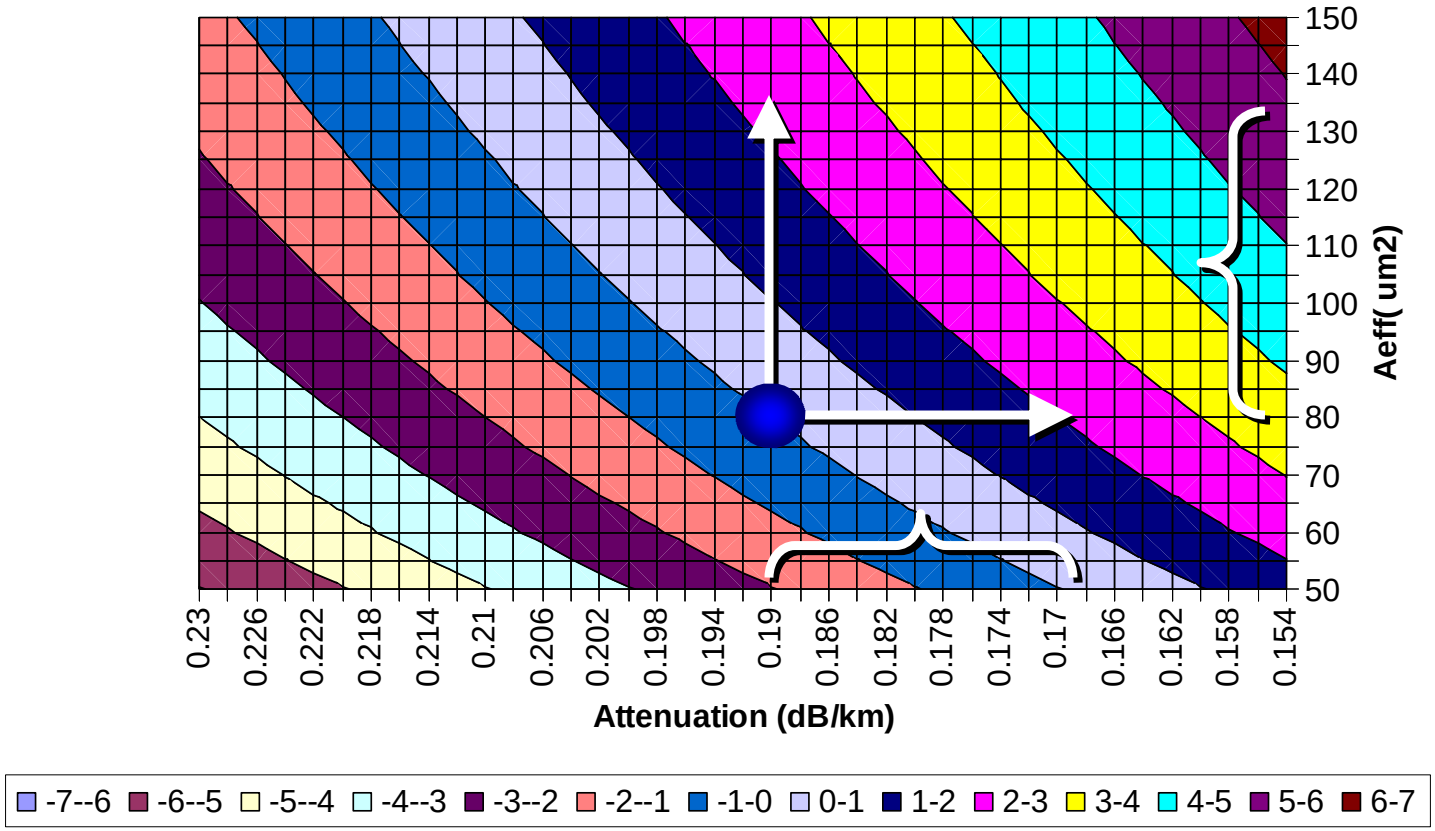
Impact of Attenuation & A_{eff} on the Fiber FOM

Example for 100km spans

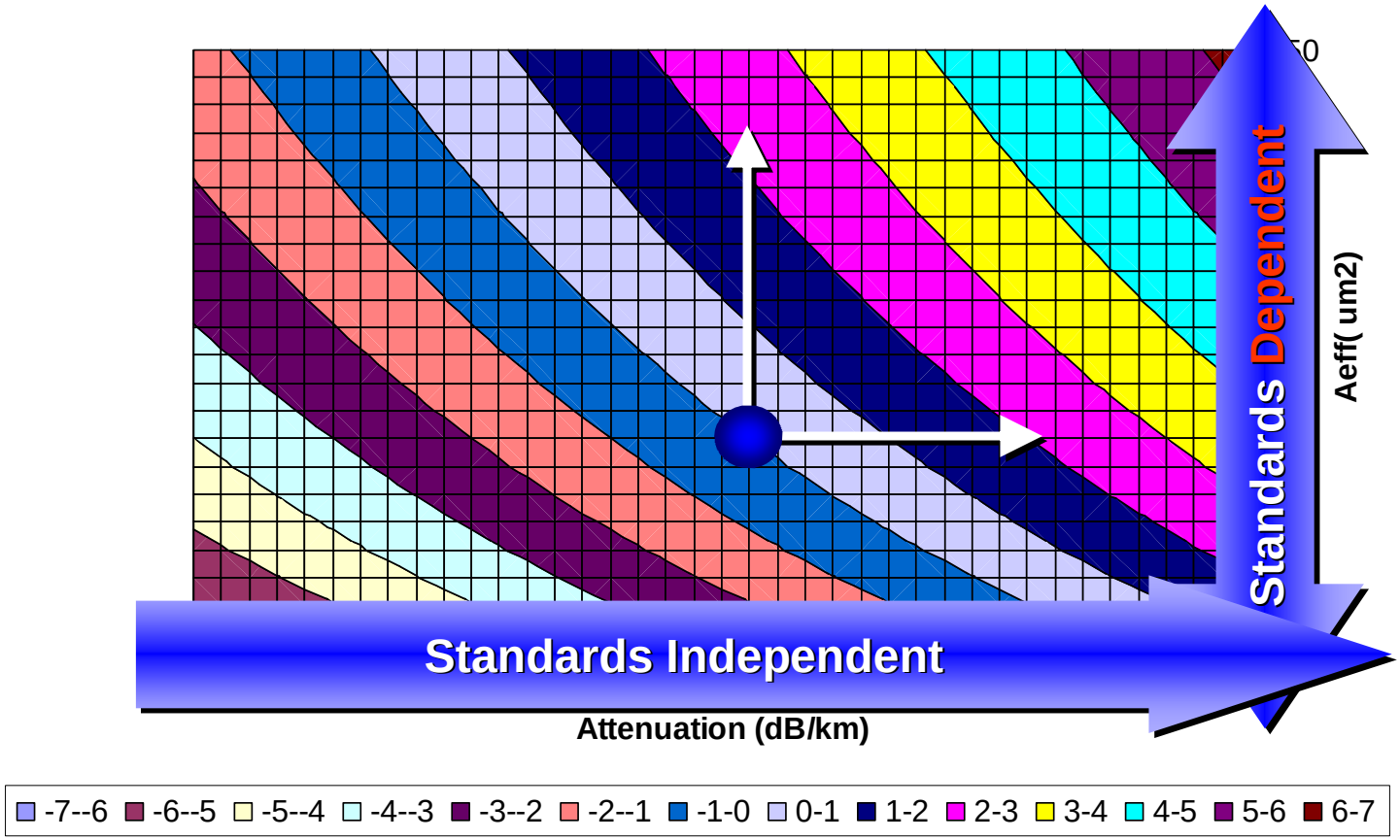


Again, If we “over simplify”:

0.02 dB/km att improv. is equivalent to 50 μm² larger Aeff



However These Two Parameters May Have Significantly Different Impact on OSP Management



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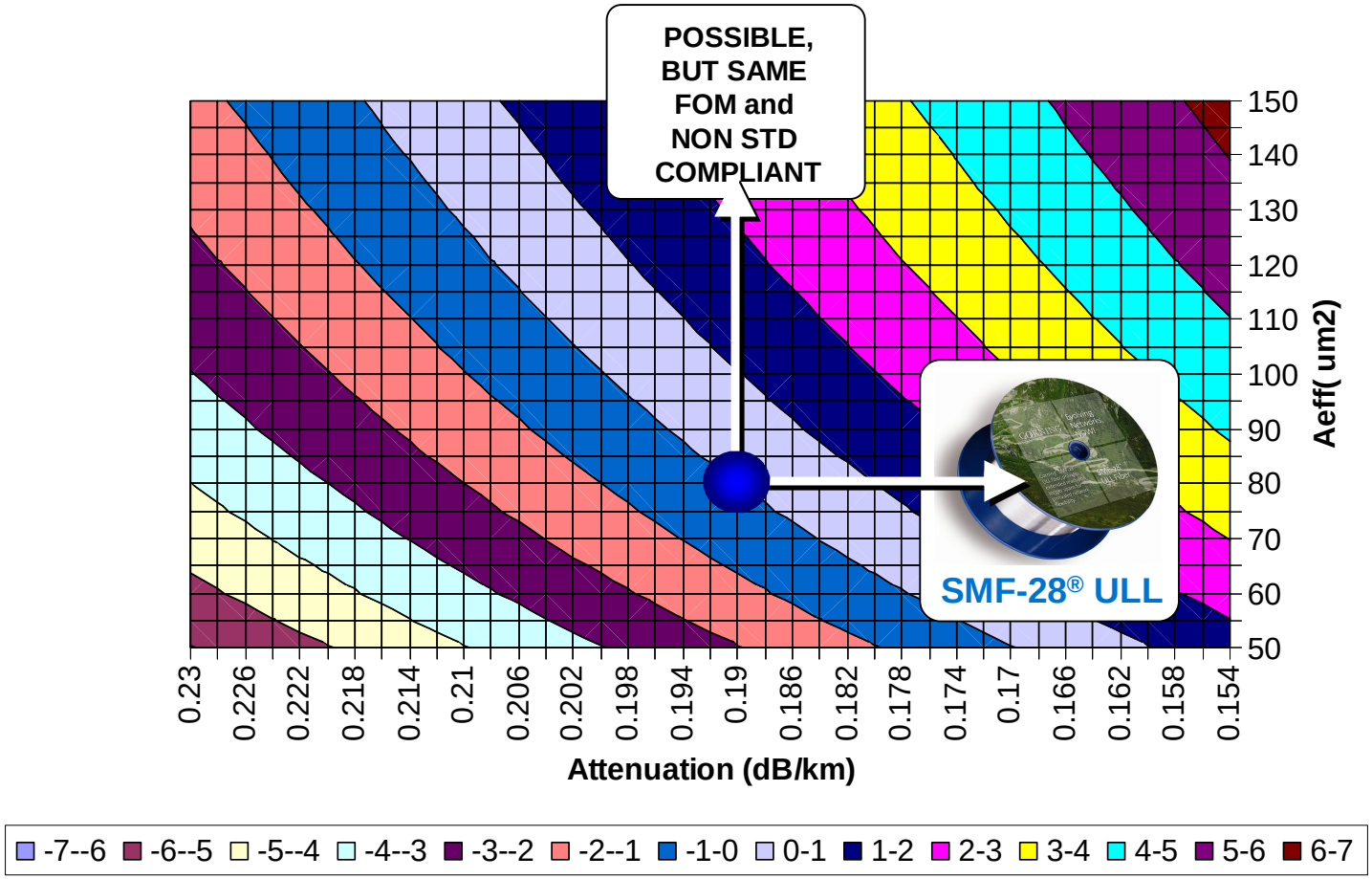
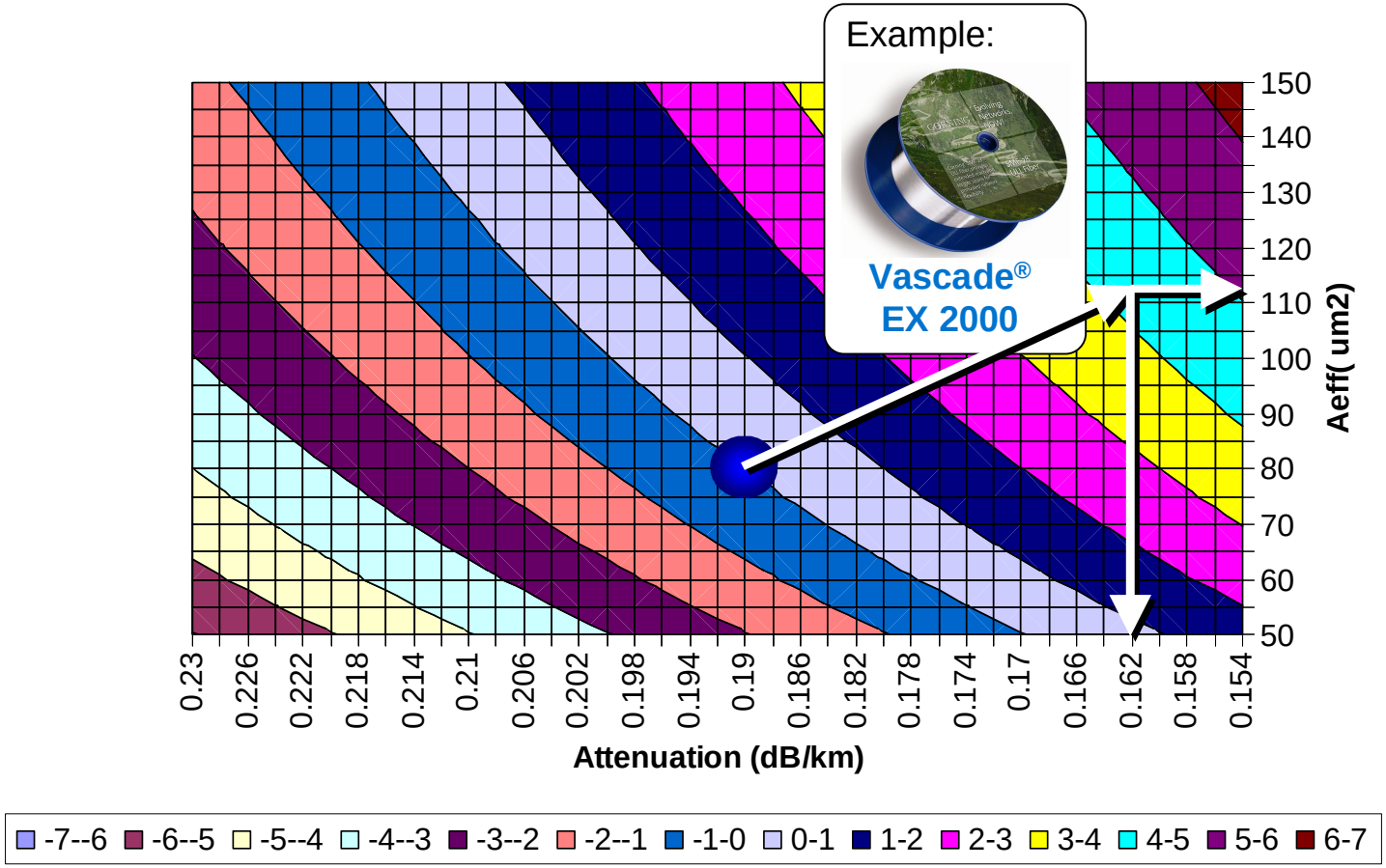
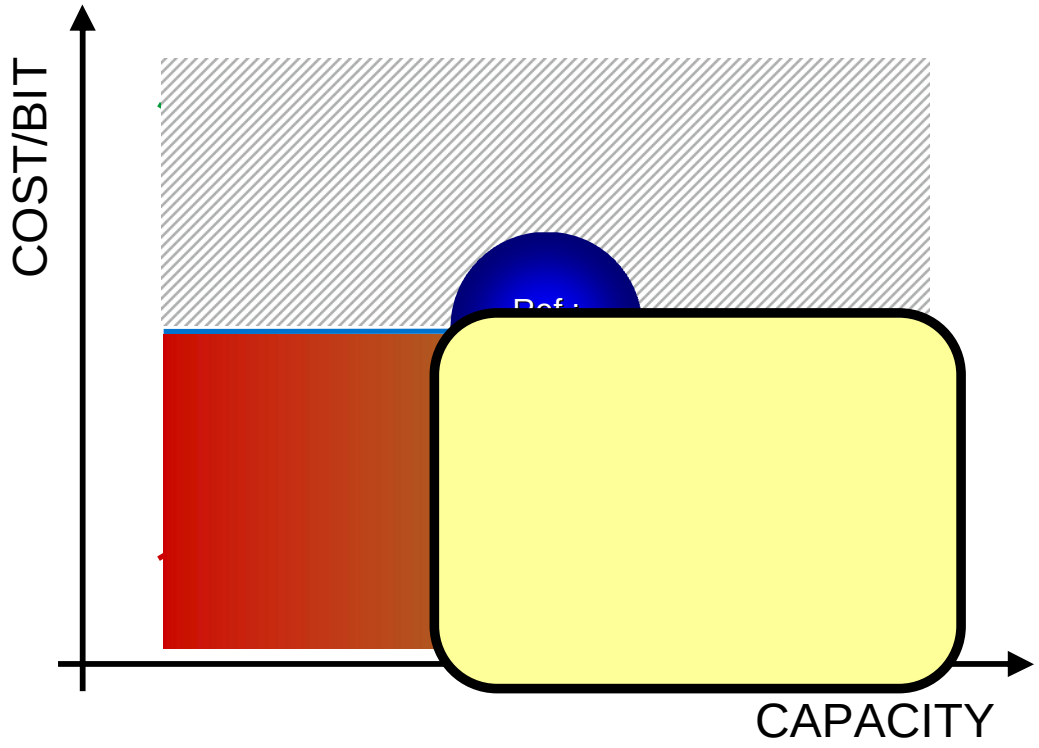


If Standards or Installed Plant Compatibility is Not an Issue, them Optimize Both Aeff and Attenuation !



Fiber Impact on Cost/Bit



Œ Reference Configuration

- Reference Fiber

Ž Not Interested in higher cost options

- How can fiber optimization reduce overall cost ?
- Let's start looking at extreme capacity demand networks

‘ Let's now look at moderate-high cap. demand networks

Fundamentals Are the Same ! So, start by keeping A_{eff} as high as possible and Attenuation as low as possible

$$\propto A_{eff} / n_2$$

$$OSNR_{out} = \frac{}{P_{ph} \cdot NF \cdot N_{Spans}}$$

Fiber Independent

$$\propto \text{Att.}$$

Fiber Effective Area

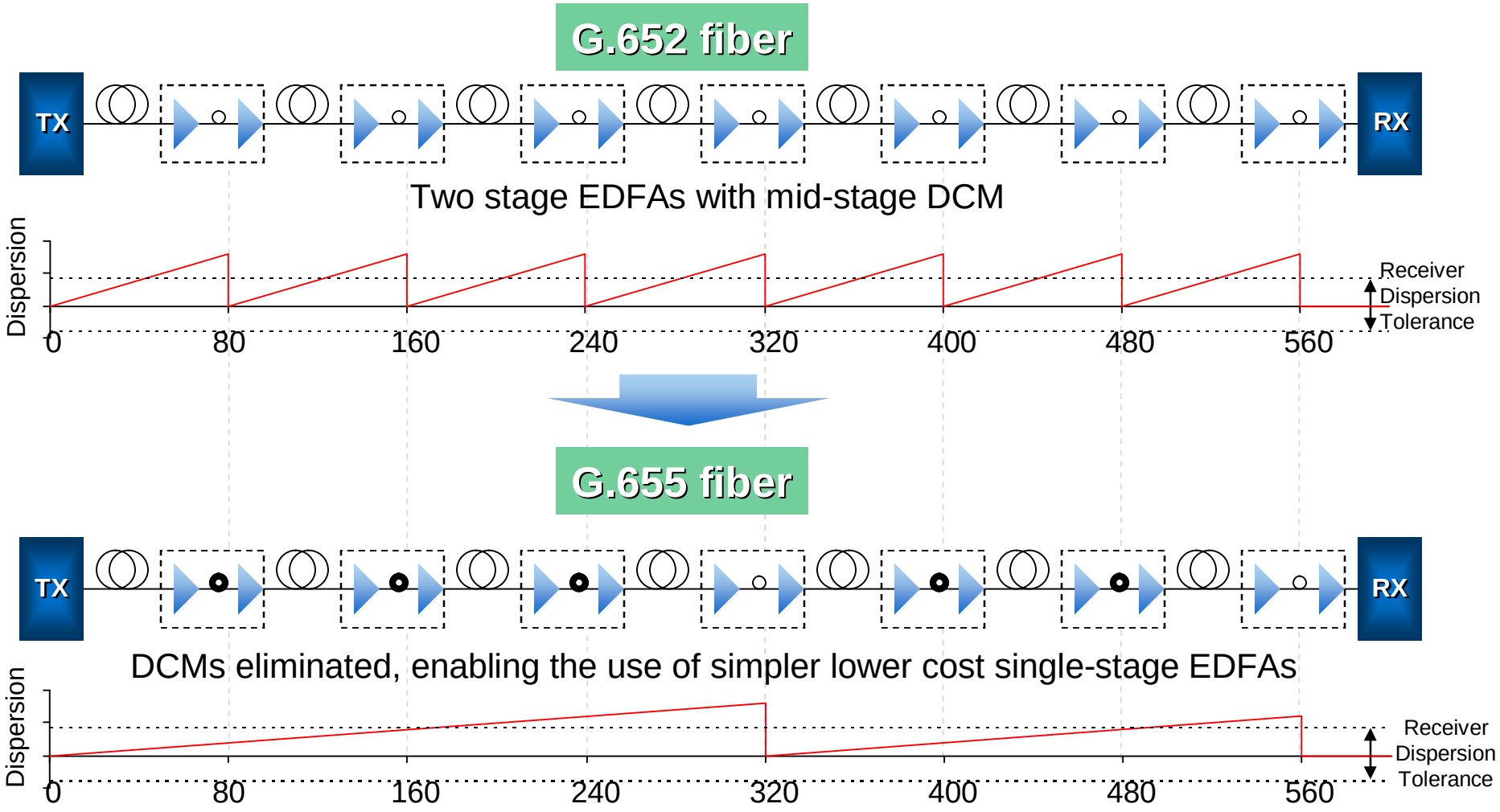
Fiber Attenuation

$$\text{Fiber FOM(dB)} \approx 10 \log\left(\frac{A_{eff,F1} \cdot n_{2,F2}}{A_{eff,F2} \cdot n_{2,F1}}\right) - (Att_{F1} - Att_{F2}) \cdot L$$

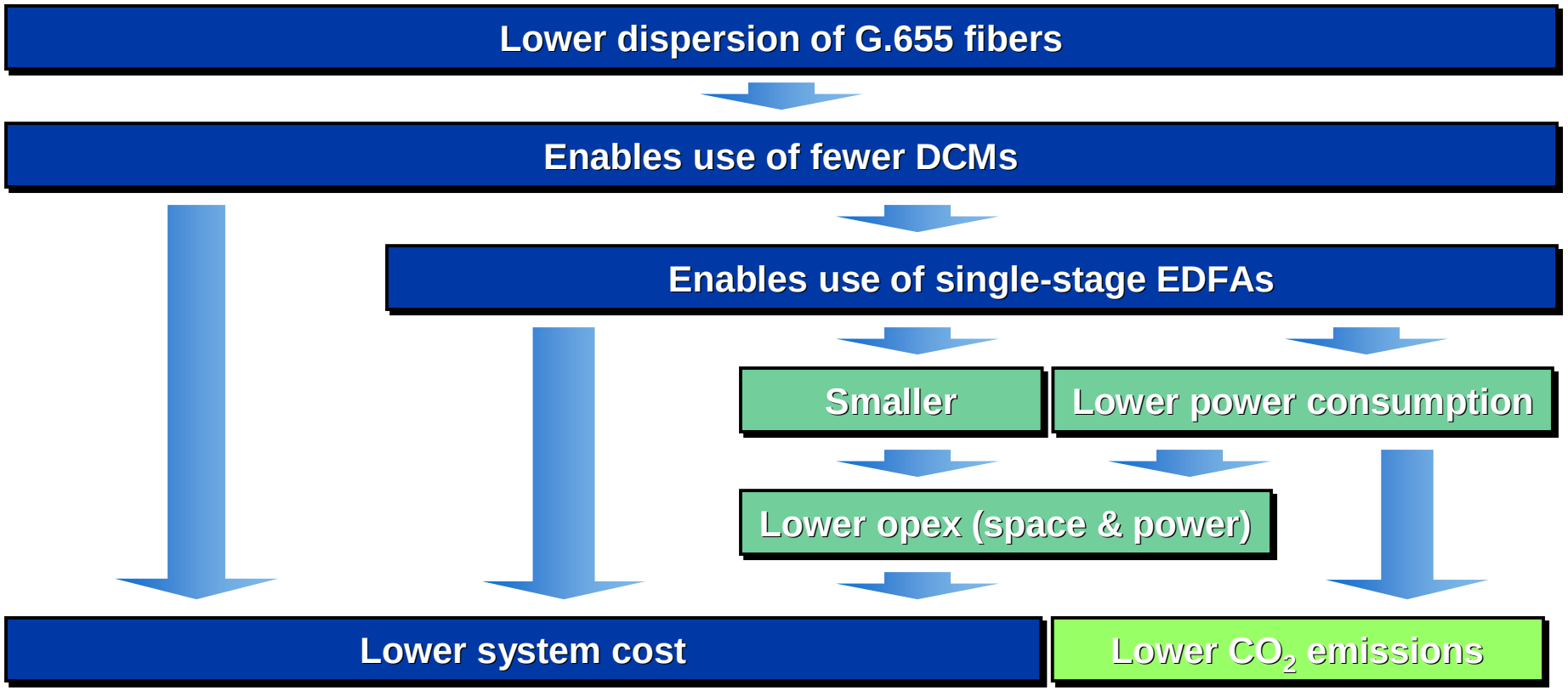
Bergano, OFC 2009, SubOptic 2010

Focus Now is Simplification - Not Ultimate Capacity

*G.655 fiber can enable reduction of DCMs **and** use of singe-stage EDFAs*

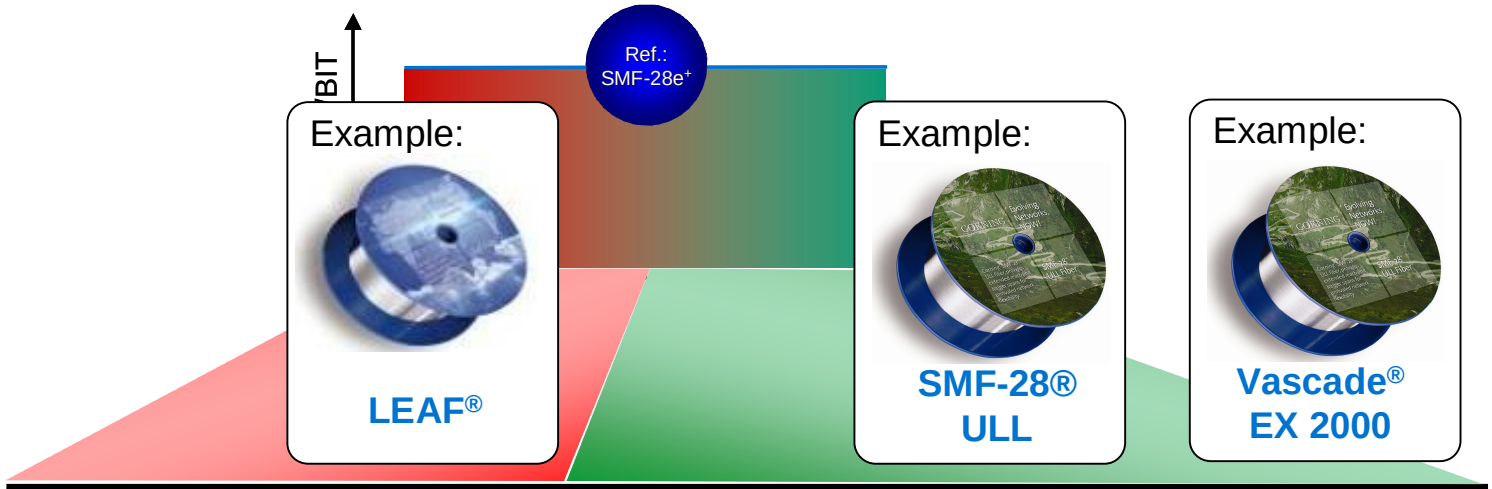


Value of Lower Dispersion Fibers in Networks Based on Simpler and Cost Effective 10 G Solutions



Summary: Extreme Capacity or Simpler Cost Effective Networks

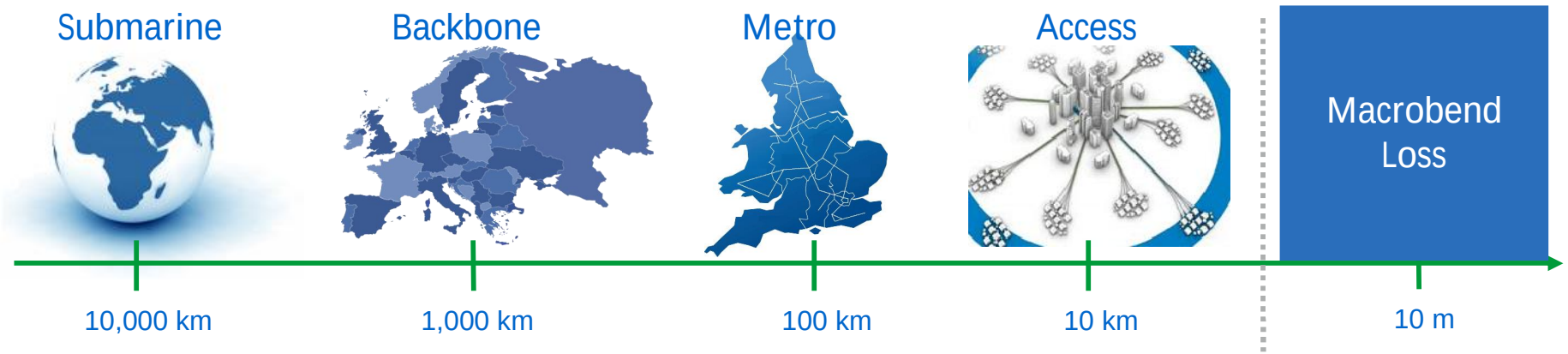
Fiber Attributes Can Make a Difference



	G.655 Ref.	Optimized	G.652 Ref.	Optimized	Optimized Non Terr. Std.
Att.:(1550 nm) [dB/km]	≤ 0.22	≤ 0.20	≤0.19	≤ 0.17	0.162
Aeff [μm^2]	60	72	84	85	112
n_2 x10^{-20} [m^2/W]	2.3	2.3	2.3	2.1	2.1
Δ OSNR* [dB]		+2.8		+2.4	+~3.5

** Calculated for 100 km fiber span. Splice losses assumed the same for each fiber type*

Innovation on Indoor Networks



Towards a Superconnected world with FTTH

Macrobend Loss

Bend Insensitive Fibre

Indoor Cabling

FTTH Fibre to the home

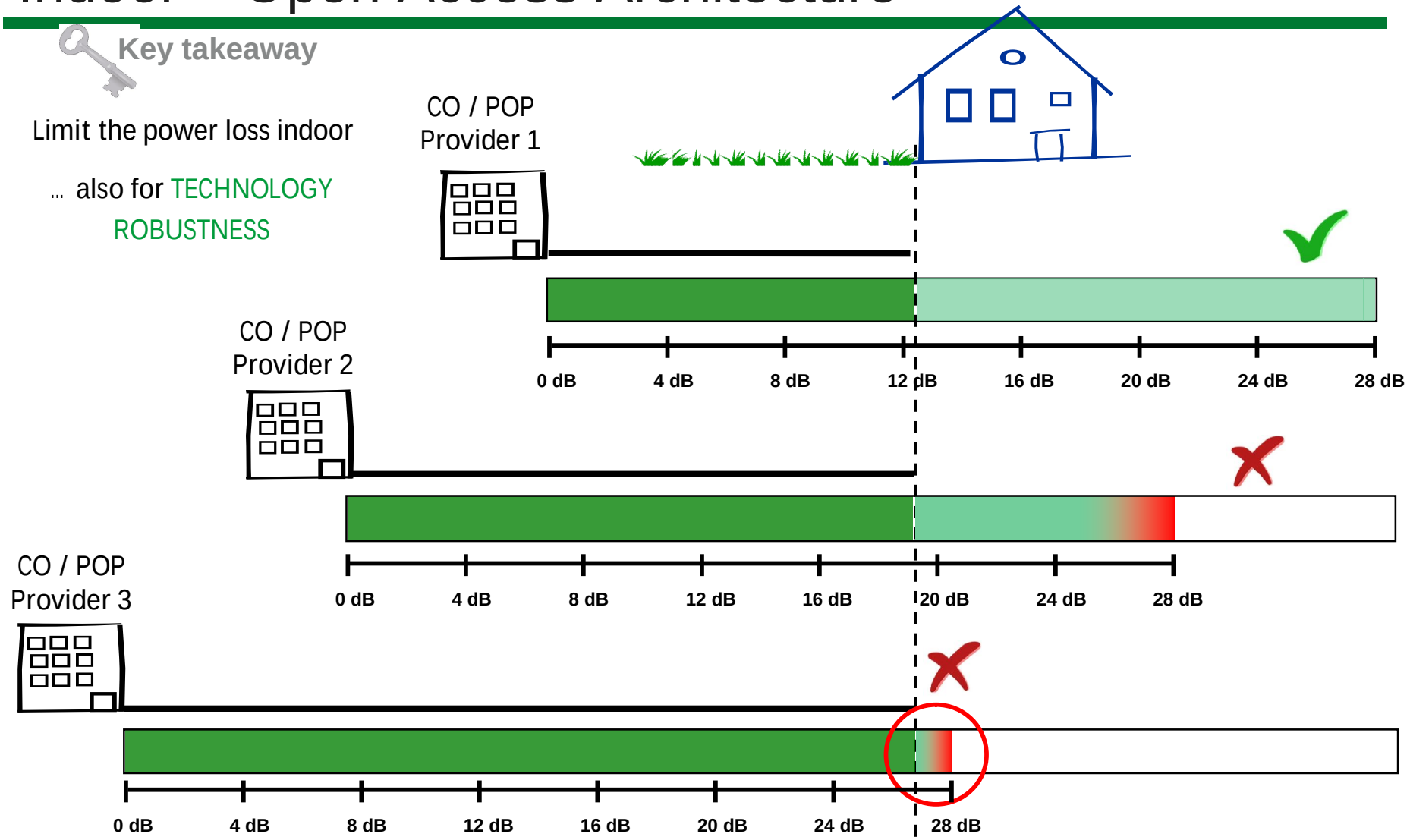
Open Access Architecture

Indoor – Open Access Architecture

Key takeaway

Limit the power loss indoor

… also for TECHNOLOGY ROBUSTNESS



Indoor - Open Access regulation in Europe

Germany

1.2 dB max

France

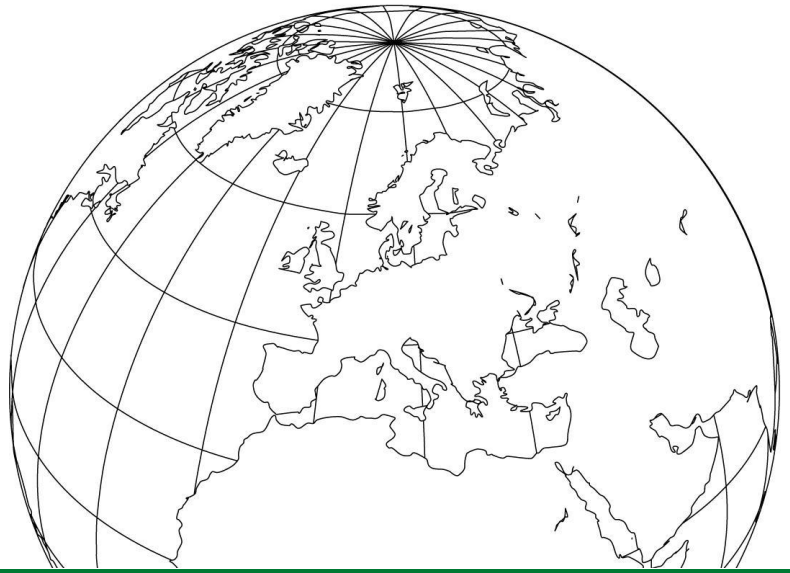
1.5 – 2dB max

Switzerland

0.9 dB max

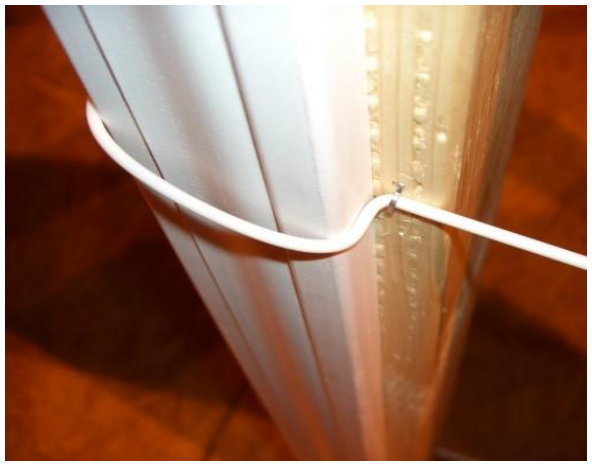
Europe (proposed)

1.2 dB max



Indoor – Fibre in the Building

Fibre is challenged as it enters the home…



New Environment

- Space constraints
- Can experience tighter bends, staples

New Installation practices/requirements

- Higher installation speed requirements
- Must install “like copper” to enable lower installation labour cost
- Meets more aggressive environment and handling
- Has an increased chance of inappropriate installation procedures

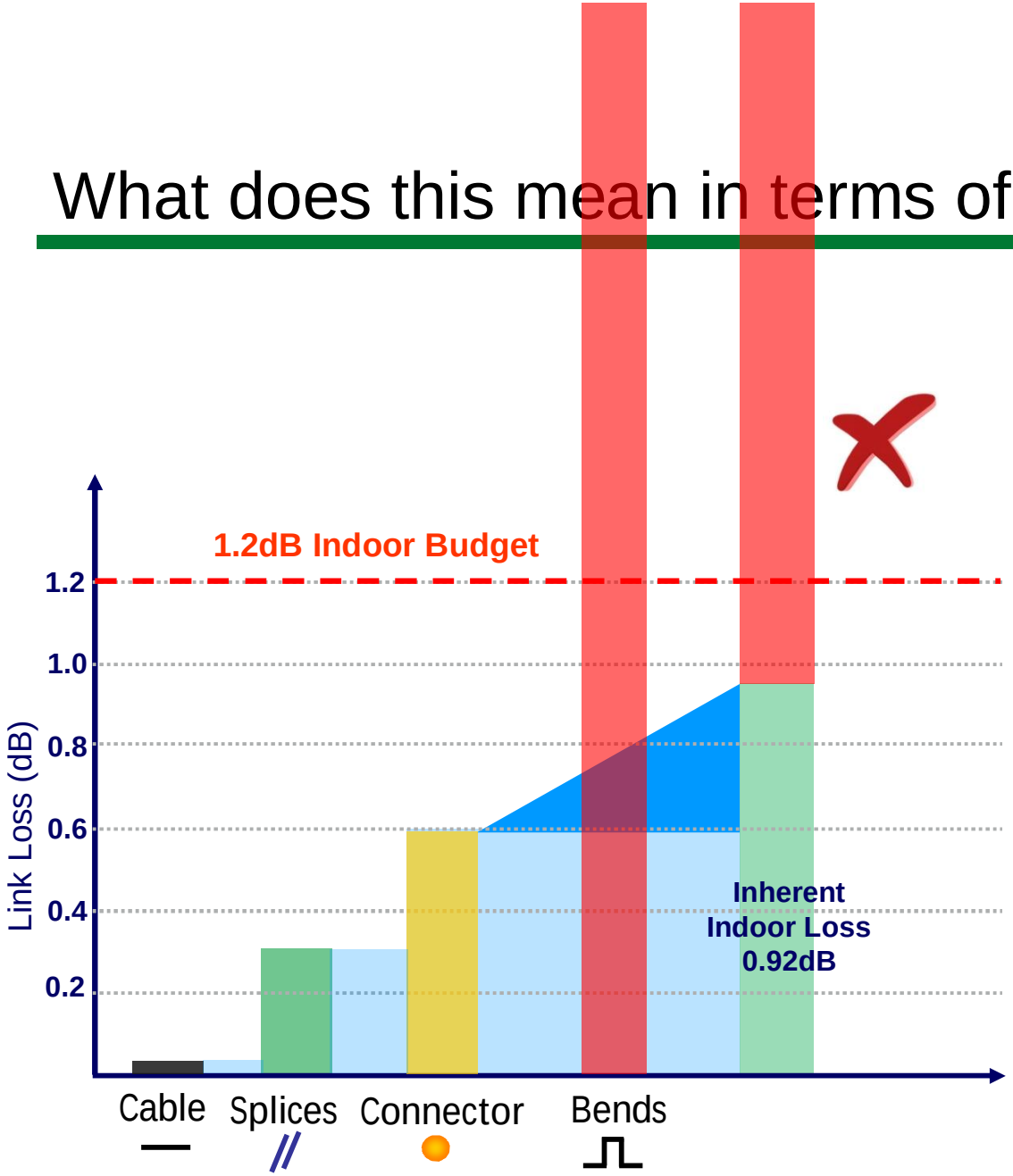
The Public

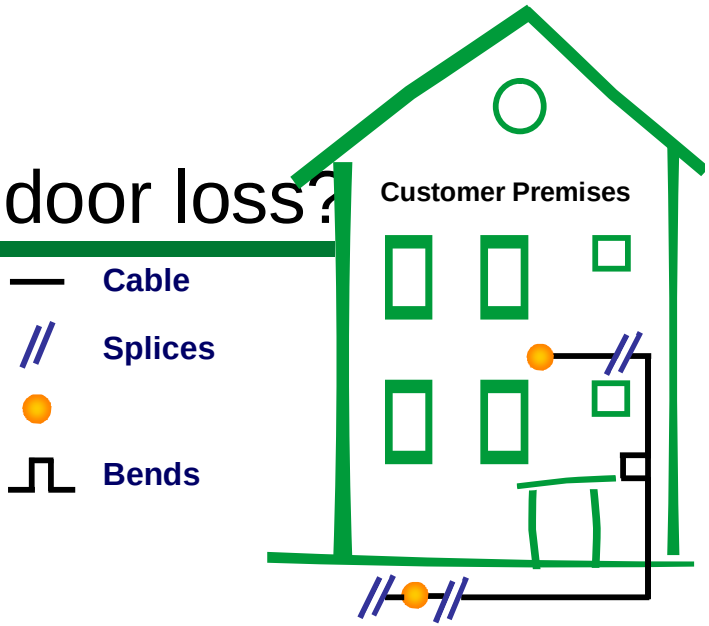
- More likely to experience unwanted/accidental public intervention
- Required to be more aesthetically pleasing

Key takeaway

The fibre is challenged by BENDs

What does this mean in terms of indoor loss?



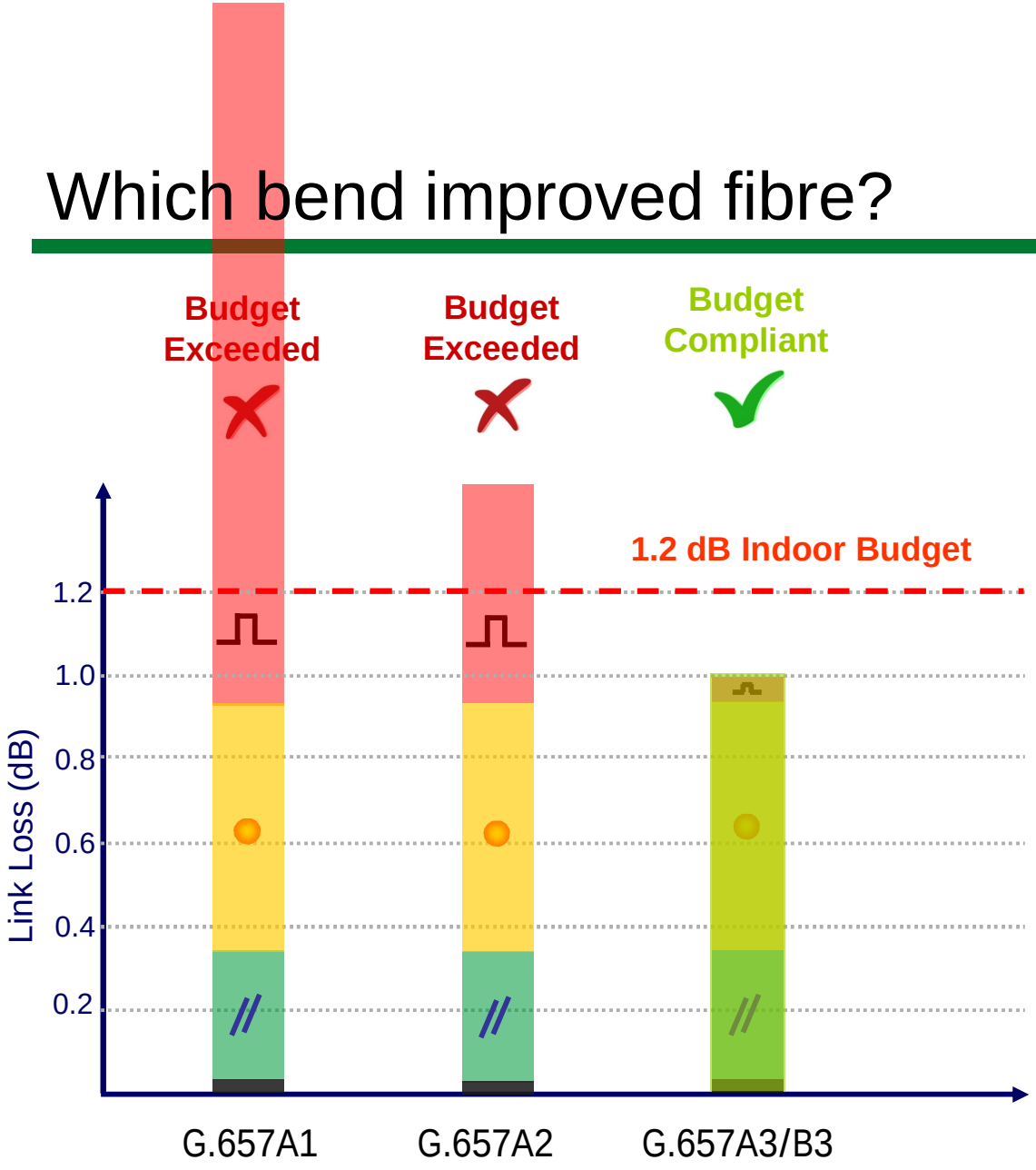


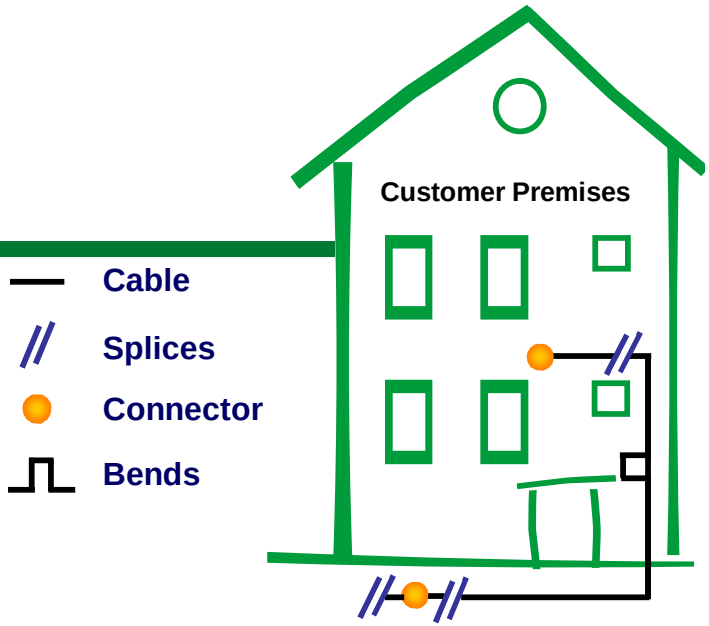
Using a standard G.652 fibre…

Key takeaway

You need a Bend Improved Fibre

Which bend improved fibre?





Add 1 full turn at 7.5 mm

Key takeaway

Only category G.657 A3/B3 truly Bend Insensitive Fibre enables compliance with indoor cabling standards

Can you ensure that these kind of things will not happen during the lifetime of your installation?

Really?

Are you 100% sure?

Key takeaway

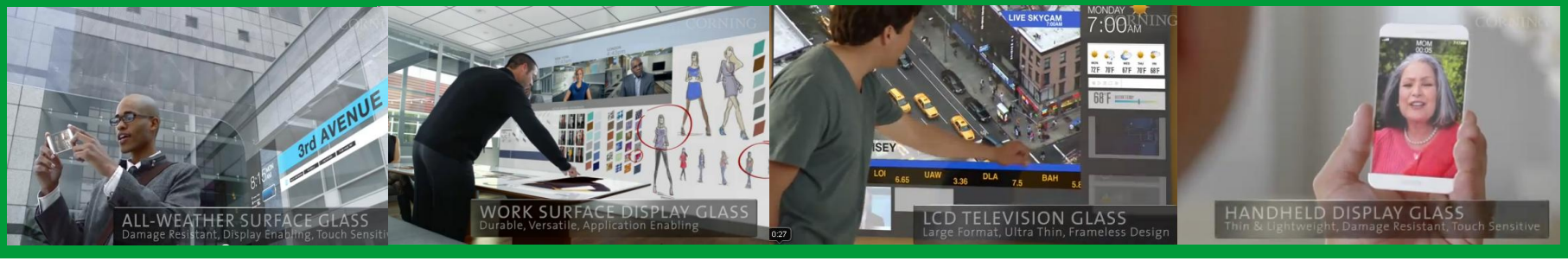
ClearCurve® ZBL Fiber

Only category G.657 A3 truly Bend Insensitive Fibre will provide lifetime protection against signal loss due to accidental bend

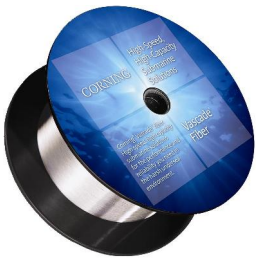
A Simple Insurance Policy!

Next Generation Networks

When a Solution matters, Innovation Matters



Vascade® Fiber



SMF-28® ULL Fiber

LEAF® Fiber

SMF-28e+® LL Fiber

ClearCurve® ZBL Fiber

CORNING

Science &
Technology

Thank You !

Aleksandra Boskovic