

Stretch Your Network Budget Through Proper Fiber Selection

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In an ideal world, resources would be unlimited. Unfortunately, in the real world that is not the case. When spending resources, most of us are constrained by some sort of budget.

In the case of installing a new long haul fiber optic network, a great deal of money is at stake. Not only is the initial capital expenditure (CAPEX) large, but operating expenses (OPEX) and the cost of future upgrades of transmission equipment must be taken into consideration.

In these networks, the costs of optical cable are relatively low. Studies show that they make up approximately one to three percent of overall spending, depending on the optical fiber count in the cable (see chart).

However, the quality and optical properties of the products represented by this expenditure can determine the future value of the entire investment. Therefore, spending another "few percent" on this part of the network can be well worth it. In fact, selecting the

optical fiber in your system carefully is a crucial step in helping to ensure the highest value for your network.

Below, we examine the economics of the decision-making process and explain how two key fiber parameters -- chromatic dispersion and PMD -- can affect your financial investment.

Economic Factors

The budget for a long haul network is fairly simple. It comprises three main components: transmission equipment, optical cable, and installation.

In the financial budgeting process, fiber is usually considered separately and falls under the purview of "outside plant" or purchasing, or a combination of the two. The buyer's objective is often to obtain the least expensive fiber that meets a set of predetermined specifications. Frequently, these specifications mirror the ITU recommendations for a certain class of optical fiber, such as G.652.D (OFS' AllWave® fiber) or G.656 (e.g., our TrueWave® fiber).

Standard are available. If specified, these products can help to:

- offer the network designer greater design freedom or flexibility
- allow the network to extend to many generations of transmission speeds beyond the initial installation and standard the network is built for
- increase the reliability of the network
- improve the ease of installation.

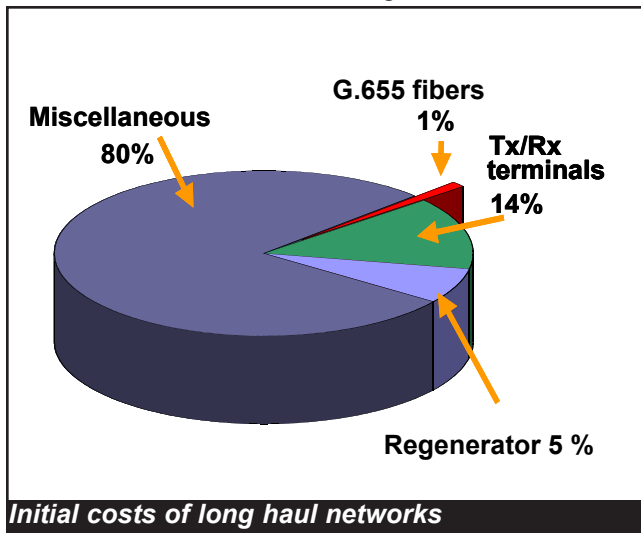
We recommend that the operator engage other parts of their organization in order to shed light upon the parameters that go into defining the total value of the investment. Adhering strictly to the "dollar budget" approach may result in initial CAPEX savings; however, this may significantly devalue the network in the long run, since very expensive modifications will be required.

Now let's discuss the two technical parameters that end users should consider when specifying their long haul networks.

Chromatic Dispersion Budget

In an optical fiber, wavelengths of light travel at different speeds, causing pulses of light to distort as they travel along the fiber. This distortion is called *chromatic dispersion*. Only a certain amount of chromatic dispersion is acceptable in order for the receiving equipment to read the signal. We may refer to that allowable portion as the chromatic dispersion "budget."

The budget depends on such factors as transmission format, data rate,



It's important to point out that the ITU recommendation, like most industry standards, was developed through consensus among a variety of manufacturers with different levels of process capability and quality. In other words, a standard is a *minimum acceptable level* of quality.

In many instances, fibers with performance levels far superior to the stan-

fiber type, etc. Technically, removing chromatic dispersion from the system is fairly simple. The most widely deployed solution is the insertion of a spool of optical fiber with a steep reversed dispersion characteristic. These spools are commonly known as Dispersion Compensating Modules (DCMs), and are available from OFS and other manufacturers.

As you upgrade to higher transmission speeds or bit rates, the chromatic dispersion budget becomes more constrained, and you are likely to need more complex DCMs, resulting in higher upgrade costs.

To minimize the need for DCMs, the industry introduced nonzero dispersion fibers, which offer limited chromatic dispersion. For example, OFS offers TrueWave RS fibers optimized for 10 Gb/s transmission, and TrueWave REACH fibers, which are designed for optimal use in 40+ Gb/s systems. What's more, TrueWave fibers provide optimized chromatic dispersion characteristics that minimize the need for complex compensation at higher speeds. This helps reduce costs while positively impacting the systems budgets for PMD and attenuation.

PMD Budget

The last budget we'll consider is the budget for *polarization mode disper-*

sion (PMD). Like chromatic dispersion, PMD is inherent to optical fiber. The important difference, however, is that while you can "buy your way out" of chromatic dispersion as described above, PMD is not easily corrected for. Therefore, it is critical to start with a fiber with low PMD.

As with chromatic dispersion, a certain amount of PMD in a given system is allowed or budgeted for. Again, the acceptable PMD level depends largely on speed and transmission formats.

Optical fibers that exceed the current standards will help make transmission of data easier and, thus, less costly.

As a rule of thumb, however, it is safe to say that the ITU recommendation for PMD is already obsolete. The standard was developed to support 10 Gb/s transmission and does not fully capture the requirements for the 40 - 100 Gb/s systems being deployed today.

OFS recommends that, at a minimum, you select an optical fiber with a PMD Link Design Value of 0.06 ps/sqrt (km) or better. For long haul systems - as well as for shorter haul networks optimizing the cost-saving potential of

reconfigurable optical add-drop multiplexers (ROADMs) and optical routing - we recommend fibers with an LDV ≤ 0.04 ps/sqrt (km) to support higher speeds.

Budgeting for the Real World

Recently we have seen a number of RFQs for nonzero dispersion fibers that refer only to a "G.655" specification. Clearly, this is an example of an operator so focussed on the dollar and chromatic dispersion budgets that they have forgotten the PMD budget altogether. While they will most likely get a cost-optimized fiber and easy chromatic dispersion compensation, their savings on DCMs will be offset by future costs of compensating for mediocre PMD performance.

As you move to 40 Gb/s and beyond, PMD becomes the most complex dispersion to manage. Deploying optical cable with ultra-low PMD minimizes this transmission impairment and simplifies the deployed electronics. As a result, the cost of future upgrades to the network can be reduced.

Remember, optical fiber systems are an investment. You should expect many years of service out of this investment, and during that time data rates are expected to skyrocket. Optical fibers that exceed the current standards will help make transmission of that data easier and reduce costs.

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