Take-Rate Economics and FTTH Network Design

Overbuilds require more careful attention to first cost, even if final buildouts are more expensive

By Guy Swindell ■ *OFS*

It was not so long ago that fiber to the home was a fringe technology advocated by a handful of vendors and a small cadre of early adopters. As we approach the end of 2006, it seems safe to say that FTTH has become the industry's preferred wireline solution. This creates a bit of a conundrum in the world of outside-plant design. The talent pool is shallow for telecommunications engineers with both significant fiber and "first-mile" experience. Furthermore, the rules for FTTH outside-plant design seem to be a moving target and often seem to originate from sources with questionable motives. The good news, however, is that impartial and unbiased analysis can allow any novice to get pointed in the right direction.

A sage old engineer once noted, *"Cost is not everything. Understanding the cost IS everything."* Nowhere is this more true than in FTTH. The most important design objective for any telecommunications network will always be functionality, of course, and functional outside plant design is not hard to achieve in FTTH.

There are rules with respect to system parameters and a dizzying number of standards related to system components. But those parameters and standards are well documented, and few are unique to FTTH. Basic functionality, therefore, is a given.

In contrast, allocating resources is complicated when you do not know how many subscribers you will connect in an overbuild scenario. The tough questions in FTTH address where and when the money will be spent, and how those expenditures must be balanced against the need to support a 30- to 40-year life span for the outside plant network.

While deploying FTTH in new "greenfield" communities is a popular topic, the real volume numbers for FTTH are now being achieved in where new networks are being deployed to compete in existing neighborhoods. Consequently, we must design around the "take-rate," or anticipated number of subscribers.

Fortunately, while take-rate assumptions are rarely better than an educated guess, one of the great strengths of an all-fiber network is the cost allocation in this scenario. Although FTTH has been frequently maligned for the cost to connect a subscriber, competitive carriers recognize that most of that cost is only incurred when you have a subscriber! Thus, the absence of intermediate electronics and signal regeneration equipment can allow you to deploy fiber into a neighborhood relatively cheaply and defer much of your expense until the moment when you have an actual paying customer.

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Contrast this with a traditional HFC network. The jury is still out on whether HFC really stands for "Hybrid Fiber Coax" or "High Fixed Costs."

So, if one of the advantages of FTTH in an overbuild application is the allocation of cost, it makes sense to carry this advantage as far as possible. Therefore, one of the paramount design metrics for FTTH is "cost-per-home-passed" versus "cost-per-subscriber."

The meaning of "cost-per-subscriber" is fairly obvious. It is generally accepted as the cost for all electronics, passive components, and installation labor required to deliver content from the central office/head-end to the subscriber.

The definition of "cost-per-home-passed" is more debatable. However, in the name of simplicity, we will define it as the cost incurred to deliver content to a neighborhood without the final cost to connect a subscriber to the infrastructure routing through the neighborhood. Graphically, the difference is shown in figures 1 and 2.

Labor Issues

The distinction between cost-per-home-passed and cost-per-subscriber is most relevant in the context of drop installation costs. Labor is typically the single largest cost for any wireline network installation, and installing the drop typically has the

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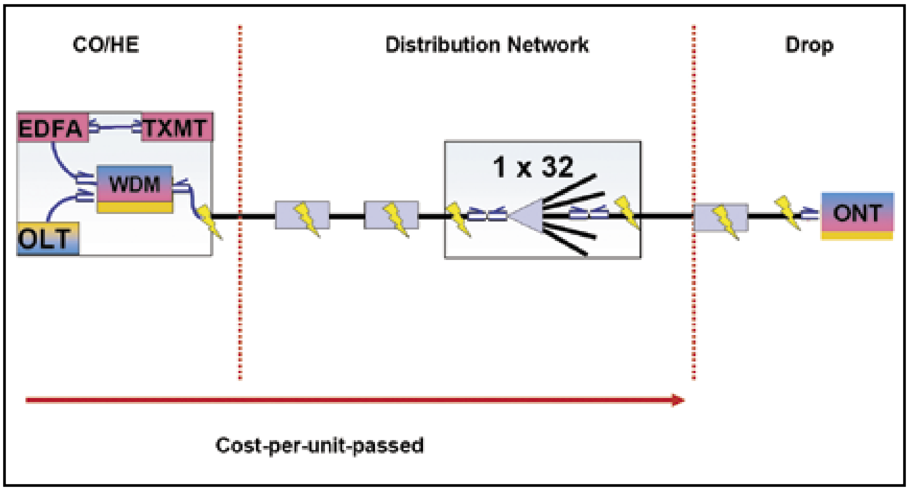

Figure 1. Cost per home passed covers all the items above, from central office to the fiber distribution hub in the neighborhood.

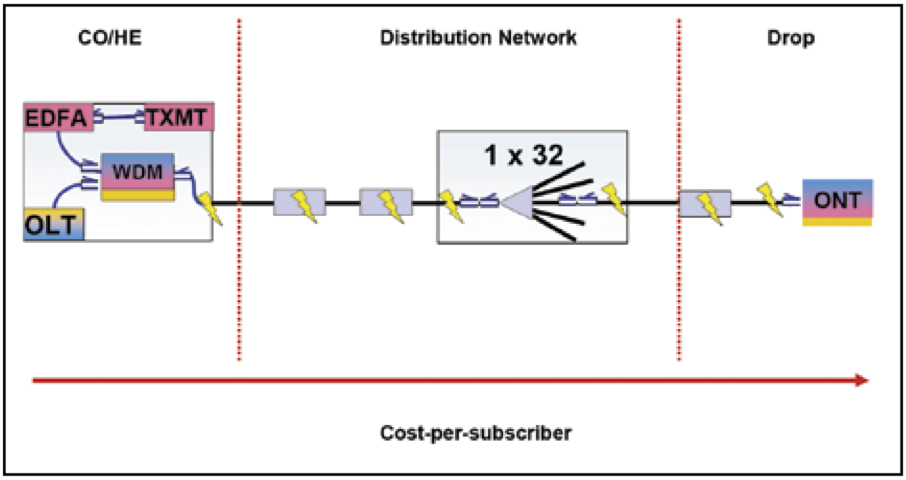

Figure 2. Cost of equipment from the fiber distribution hub to the subscriber has to be added to get the final outside plant cost per subscriber.

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largest overall impact on the cost-per-subscriber.

Thus, a great deal of attention has been given to FTTH solutions that mitigate some drop labor costs by reducing splice and cable prep time. This labor cost reduction is achieved by positioning materials, which enable the use of pre-connectorized drop cables. In effect, a tradeoff is made between material expense and labor expense.

Occasionally, this is a good idea. A cheap calculator and some basic math skills will allow the prudent designer to calculate the hourly labor rate and the actual amount of labor time saved, and compare that number to the cost of additional materials and up-front engineering expense for the pre-connectorized solution.

But for the competitive overbuilder, those calculations must be closely tied to the business plan. An up-front addition of materials represents a cost-shift in the wrong direction. Labor costs are only incurred for drop installation when you have already signed a paying customer. Added material costs to reduce the cost of that same drop installation are incurred earlier in the process. Therefore, the cost-per-home-passed is increased with a corresponding increase in the risk associated with an unknown take-rate. The right decision has as much to do with business planning as engineering, and will vary from one carrier to the next.

If cost-per-home-passed is a key concept for overbuilders, it shares equal billing with a concept sometimes referred to as the "cost-of-inefficiency." The cost of FTTH has decreased dramatically over the last few years, but it is not yet free! Some up-front investment is always required.

Consider, for example, the typical scenario of a carrier that shifts from a metallic media first-mile solution to PON-based FTTH. At a minimum, the customer must purchase an OLT (Optical Line Termi-

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nal) for the central office. If traditional RF video is being supported, that OLT investment likely includes additional costs for RF transmitters, erbium-doped fiber amplifiers, and the optics required to multiplex that RF content onto the same fiber as the other PON services.

In North America, all of those OLT and RF overlay components would typically add up to somewhere in the neighborhood of $250 per subscriber in central office cost. However, that "per subscriber" number carries the assumption that the equipment is being deployed at full capacity. So, for PON, it means that each port on the OLT is serving 32 customers. Such a full-capacity deployment can be difficult to achieve. If the OLT port has only 16 customers, 8 customers, or 4 customers, the cost of unused central office capacity would look something like the graph in Figure 3.

From an outside plant design vantage point, it is more helpful to think of the costs of unused OLT capacity as an "inefficiency cost." If the base per-subscriber cost of the OLT is $250, there is nothing the outside plant engineer can do to mitigate

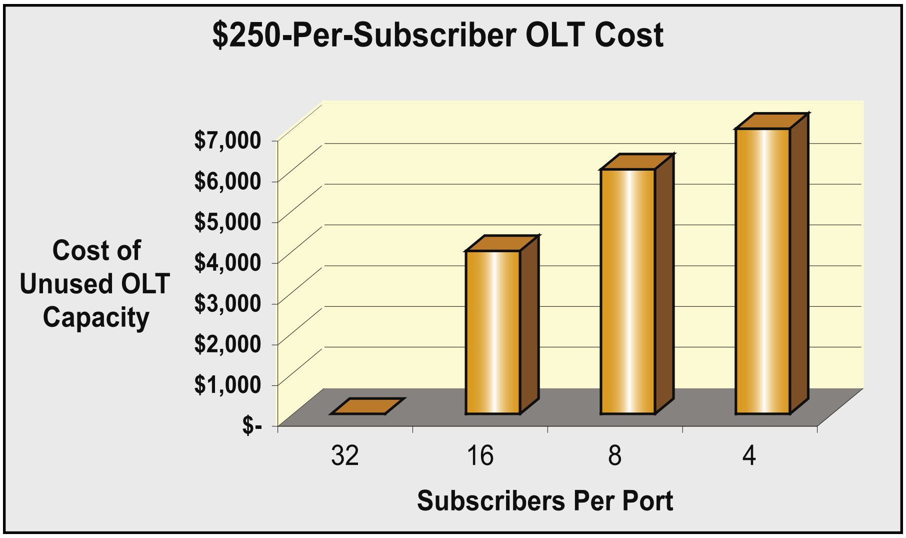

Figure 3. Cost of unused OLT capacity in the central office decreases quickly, as the number of subscribers per port increases.

Current practice trades off materials cost for reduced labor cost. But for the competitive overbuilder, those calculations must be closely tied to the business plan. An up-front addition of materials represents a cost-shift in the wrong direction. Labor costs are only incurred for drop installation when you have already signed a paying customer.

that expense.

On the other hand, there are tactics that can be adopted in the outside plant design to help each port in the central office reach full capacity. Every tactic carries a price tag. So, we must fully understand the costs of inefficiency before we make those investments.

If the $250 per-subscriber OLT only sees 50 percent usage, then each subscriber bears twice as much (or $500) worth of central office expense. Half of that total cost is the base price-per-subscriber of the equipment, while the other half is the inefficiency cost of only achieving a 50 percent take-rate. If we chart that inefficiency cost relative to take rate, it looks like Figure 4.

Cost of Inefficiency

For PON-based FTTH, this inefficiency cost usually accompanies something known as a “distributed architecture” (figure 5). In a distributed architecture, the optical splitters are fusion spliced into closures in the neighborhood close to subscribers. It is an inexpensive and robust way to build a FTTH outside plant system, but there is a direct correlation between an unused splitter port and unused OLT capacity. Basically, unless all 32 subscribers sign up in the area where you dropped the 1x32 splitter, you are carrying some extra OLT cost.

The tactic used by outside plant designers to mitigate the cost of OLT inefficiency is to deploy something known as a “centralized architecture” (figure 6). In the centralized architecture, all of the potential subscribers in a particular area are routed back to a cabinet – a “fiber distribution hub” – where the optical splitting takes place.

If everybody deploys a $250-per-subscriber OLT, this math is a no-brainer. The centralized cabinet pays for itself at anything below a 70 percent take-rate. However, the astute international traveler will note that Japan leads the world in FTTH deployment and yet there are few, if any, big centralized fiber cabinets in Tokyo.

This cabinet will typically serve around 288 subscribers.

The beauty of this system is that a single OLT port routes to a single splitter, and that single splitter can connect to any of a larger number of subscribers (up to 288 if it is a 288 subscriber cabinet). Therefore, we have greatly increased the possibility of getting the full capacity from our OLT port

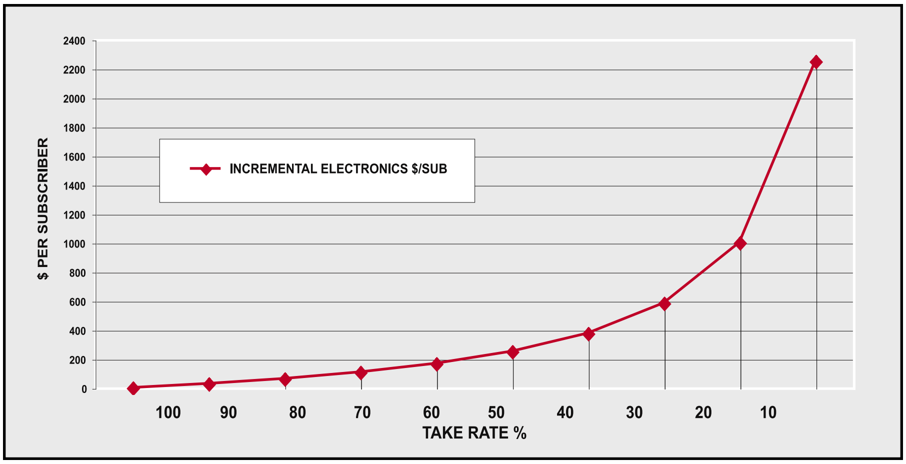

Figure 4. OLT inefficiency cost, at $250 per subscriber.

IP video systems are beginning to proliferate (eliminating RF overlay components), and there is a broad spectrum of OLT products on the market. How much does your central office gear cost, and how much will it cost to deploy a cabinet?

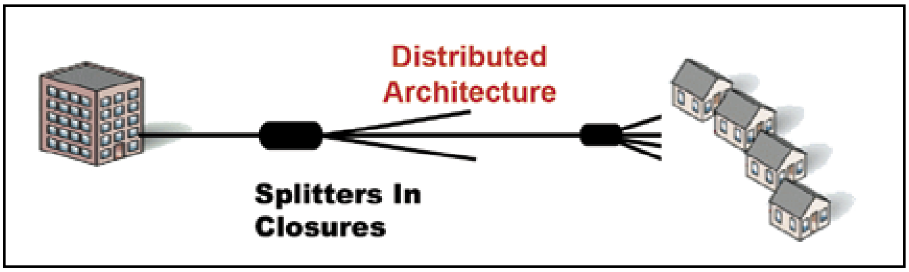

Figure 5. Typical PON distributed architecture.

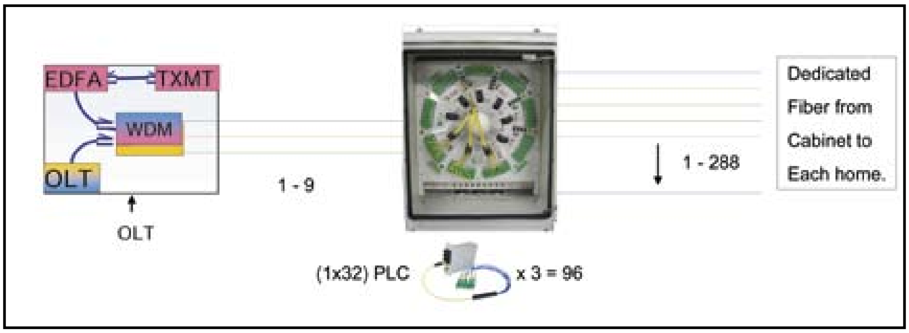

Figure 6. Typical centralized scheme, with fewer or no fiber distribution hubs in the neighborhood.

and from our splitter in the field.

Of course, the cabinet is a large box that occupies a potentially expensive piece of real estate and is chock-full of connectors, jumpers, splitters, and so forth. Also, the centralized architecture means larger fiber count cables routed through the neighborhood. In short, we have paid a price to increase our OLT efficiency. And, once again, this cost increases as the take-rate decreases. If we figure our additional cost for a centralized architecture at about $75 per-subscriber at full capacity, and chart our increase in cost as the take-rate goes down, we can compare it to the OLT inefficiency cost (Figure 7).

Centralize?

If everybody deploys a $250-per-subscriber OLT, this math is a no-brainer. The centralized cabinet pays for itself at anything below a 70 percent take-rate. However, the astute international traveler will note that Japan leads the world in FTTH deployment and yet there are few, if any, big centralized fiber cabinets in Tokyo.

Pundits like to use population density as the answer to every question that invites comparison between Japanese and North American FTTH deployments. In reality, the same graph still applies. It so happens that most FTTH activity in Japan is data-centric. That is, there is no expensive RF video overlay and no legacy telephone service delivered over most FTTH systems. Therefore, the OLT cost-per-subscriber is probably at or below $100 per subscriber in Japan.

Also, let us assume that a piece of real estate in Tokyo is more expensive than in Middle America. Therefore, we will plug in $100 per-subscriber for our centralized cabinet cost (figure 8). With those numbers, the lines never cross between OLT inefficiency and cabinet expenses. Consequently, the prudent course of action is to live with inefficiency at the central office.

All-Digital Pays

Where does this leave the North American outside plant design engineer? The obvious answer is that designers need to understand the cost relationship between central office efficiency and outside plant architecture. IP video systems are beginning to proliferate (eliminating RF overlay components), and there is a broad spectrum of OLT products on the market. How much does your central office gear cost, and how much will it cost to deploy a cabinet? Those dollar figures must be understood.

There is a school of thought that sug-

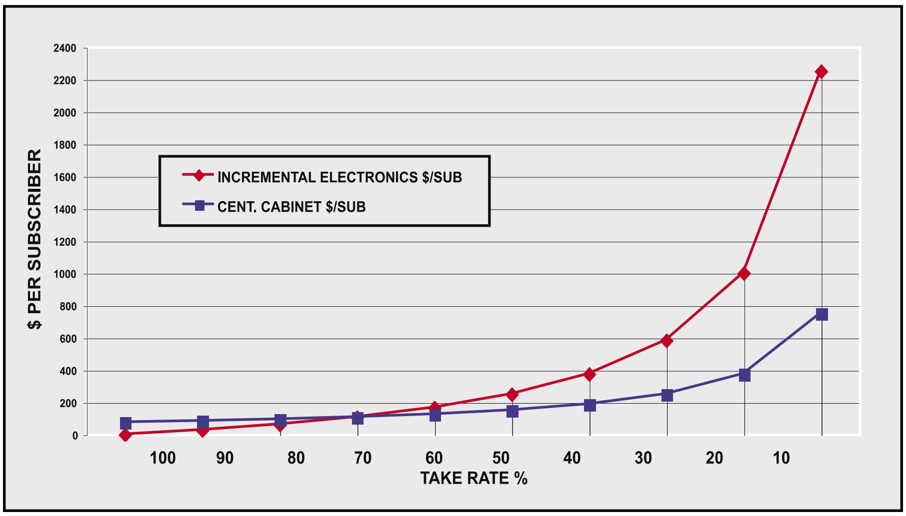

Figure 7. OLT inefficiency versus centralized fiber distribution hub cabinet costs.

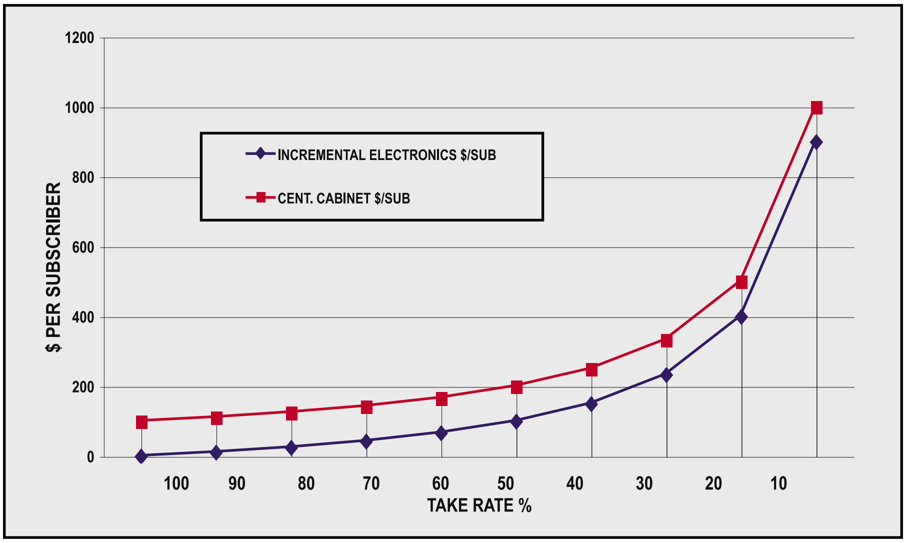

Figure 8. OLT Inefficiency vs Centralized Cabinet Costs; $100-per-sub OLT / $100-per-sub Cabinet. At $100 per subscriber, the centralized splitter approach pays at any take rate.

gests centralized architectures and cabinets are the prudent deployment choice regardless of OLT costs or take-rates. The staunchest advocates of this theory tend to be vendors selling cabinets, and the leading argument tends to be the ease of testing and troubleshooting a centralized architecture.

This argument is legitimate, but weak. Testing a centralized architecture can be a little easier, but FTTH troubleshooting is distinguished by the fact that an intelligent and manageable device (the ONT) resides at the customer premise. Therefore, it is relatively simple to isolate faults in any outside plant architecture that is properly documented. Likewise, it is nearly impossible to isolate faults in a system that is not properly documented – centralized or not. Furthermore, centralized architectures introduce additional connectors into the network, and connectors typically constitute a majority of faults over the lifespan of the outside plant. So, installing a cabinet to ease testing and troubleshooting is a Faustian bargain.

A very legitimate, and seldom noted, advantage of a centralized architecture is the ability to easily replace, modify or upgrade the optical splitters deployed in the field. This idea epitomizes the principal noted by our sage engineer at the beginning of this article: *Cost is not everything. Understanding the cost IS everything.*

The outside plant is expected to last thirty to forty years. For PON-based FTTH, today's optical fiber and cable should be up to the task. However, will we be using the same splitter configuration thirty years from now? Possibly not.

There are a number of factors that could impact that portion of the network. For example, if bandwidth growth outpaces product development and interoperability, the logical solution may be to reduce the split ratio from 1x32 to 1x16. Or, if the technology roadmap leads to solutions that support DWDM or CWDM (dense or coarse wave-division multiplexing – to put multiple wavelengths on one fiber) for the delivery of additional wavelengths to customers, splitter configurations may also require modification.

For that matter, what if an optical splitter simply becomes damaged or proves defective? These scenarios can be difficult to manage if splitters are dispersed among splice closures over a broad geographic area.

If the upgradeability advantage of cabinets ranks immediately behind take-rate management as a selling point of the centralized architecture, the market has largely missed this point. In the interest of eliminating costs and connectors, many cabinets deployed today are nearly impossible to upgrade. Changing a splitter is an infuriating process of tracing jumpers and charting connectors while customers potentially sit for hours without service.

A handful of products on the market have sought to address this deficiency with splitter modules that support the easy upgrade objective. If an outside plant architecture is going to carry a cost premium, the outside plant engineer should understand the rationale behind that additional cost. In the case of a centralized architecture, the premium is justified by take-rate cost controls for the central office and upgradeability for the passive plant. Cabinets, therefore, should be evaluated on the basis of their ability to manage fiber in the haphazard pattern that accompanies an unknown take-rate, and on their ability to support the easy upgrade or change-out of optical splitters.

At the end of the day, FTTH outside plant design is not rocket science. It is, however, definitely a science. As such, there are no intelligent cookie-cutter designs and no one-design-fits-all magic formulas.

It is imperative in every case to understand the cost relationships, and the business plan. Competitive carriers can easily define impartial criteria to separate engineering fact from marketing fiction around the subject of take-rate costs. Once those criteria are defined, the designer will understand not only "where" the money is spent, but also "when" and "why." With that knowledge, the right pieces fall into place. **BBP**

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