A Review Of:

Air-Blown Fiber Optic Cabling Technology

At The

University of California, Riverside

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Executive Summary:

Air Blown Fiber (ABF) has been used by the University of California, Riverside (UCR) in a campus-wide fiber optic backbone applications for more than three (3) years. Initially, ABF technology was implemented as a replacement for an existing "conventional" fiber optic backbone which began installation in 1990. It has also been used as a replacement for a much larger expansion of the "conventional" fiber network that was in the planning process when ABF technology was first introduced to UCR in 1992.

The selection of ABF technology was the result of rigorous study and detailed analysis conducted by the UCR Telecommunications Department. Economic analysis included information gained from numerous sources, including; outside cabling vendors, system design and project management consultants, other major Universities, and historical data gained from past UCR projects. In addition, representatives of the Telecommunications Department conducted on-site inspections of other major ABF installations (including the University of Utah) as part of the evaluation.

Initial ABF pilot projects at UCR also provided an excellent environment for extensive first-hand evaluation. In all, five (5) pilot projects were completed using ABF technology prior to its selection for a Campus-wide backbone. During all five pilot projects, ABF consistently yielded impressive cost savings (44% total savings) and demonstrated the ease of installation. Extensive field testing during these projects also revealed that the "stress-free" air-blown installation process yielded "perfect" results in all areas of cable performance evaluation.

With the first large-scale ABF deployment project (completed in January of 1994), many significant benefits were additionally confirmed:

- The project was completed in just four (4) months instead of the twelve (12) months planned for a similar conventional fiber project.

- Overall ABF system costs had reached $379,000 . This is in stark contrast to the $3,513,000 in expenditures forecast through the same period if conventional fiber were to be used.

- The ABF system included many important design features such as 90% surplus (growth) capacity. It also featured a multiple (diverse) routing scheme along all of the primary pathways. This was a very desirable inclusion given the extensive construction activities planned for the campus. However, it was thought to be far too costly to include if conventional fiber was to be deployed.

- It also provided a practical fit within the limited confines of the existing conduit system. Much of this system was dated, over-utilized , and generally acknowledged to be unacceptable as a host for a new fiber backbone. With ABF, plans for a costly and highly disruptive conduit upgrade program were eliminated altogether.

As of January 1996, ABF technology has continued to prove itself through a most demanding period at UCR. The Campus is being readied to support growth from a current capacity of less than 10,000 students to a long-range capacity reaching up to 30,000. An unprecedented number of building construction and renovation projects are underway. Explosive growth in LAN technology, a new distributed telephone system, and other types of communication applications have also risen. During all of this, ABF has proven to be the ideal solution:

- As of January 1996, the number of fiber optic cables installed within the ABF system has more than tripled. The current system utilization is still approximately 10%, with the remaining 90% of the system capacity being reserved for continued growth.

- The system has been installed primarily using a point-to-point cable architecture. When combined with the stress-free cable installation process and inherently reliable family of additional components, the system has achieved a truly flawless performance record. To date, there has not been a single failure in any portion of the ABF system.

- Requests for new cables have also been met with an unprecedented level of service delivery. All requests for new fiber optic cables are completed within 1/2 day from the time that the request is initiated. Related cable installation labor costs are also very small ($168 per-cable) and completely predictable.

- The overall system has been meticulously documented through each successive change using informative CAD based drawings and other automated tools.

- Most importantly, ABF technology has resulted in tremendous savings in capital expenditures. As of January 1, 1996, total ABF system costs were $692,000 compared with forecasted costs of $3,213,000 for a conventional fiber backbone. A five-year forecast of total ABF costs are expected to reach $850,000 compared to more than $3,800,000 forecasted for a conventional fiber backbone.

U.C. Riverside Background Information:

Recognizing the need for research into the methods and problems of citrus agriculture, the University of California established an experimental orchard and research center in 1907 on 30 acres of leased land. The University of California's College of Agriculture, which administered the program and facility, recognized the need for a larger station where citrus as well as other crops could be studied. As a consequence, in 1917 the University of California acquired 370 acres from the City of Riverside. And the first Citrus Experiment Station facilities were formally dedicated in 1918.

The University of California, Riverside had its official beginning in 1948, when a committee of the State Legislature recommended that a small liberal arts college be established in proximity to the Citrus Experimental Station. In April 1951, a College of Letters and Science was approved and ground was broken for an initial building. Additional lands were also acquired bringing the combined total to approximately 1000 acres. By 1954, a compliment of additional core campus buildings were also completed. Classes began in February of that year with a faculty of 55, a student body of 117, and a planned capacity for 1,500. During the next few years, additional buildings (including surplus military housing) were added. Enrollment objectives were revised upward and a Campus Master Plan based on an enrollment of 5,000 was endorsed by the Regents.

The academic mission of UCR was expanded in 1959 when the Regents declared it to be a "General Campus", thus beginning the planning for a larger, more diversified institution. The enrollment objective was raised to 10,000. In 1964, the adoption of a long-range Development Plan (LRDP) rapidly added many additional buildings.

During the 1970's and 1980' little growth occurred on the Campus. This, despite the fact that Riverside/San Bernadino County area was the fastest growing region in the State between 1970 and 1984.

Today, UCR is experiencing the most dramatic growth in its history. A new LRDP has been adopted to plan the continued growth to replace the previous plan of 1964. Current plans call for a student population of 15,000 by the year 2005 with a build-out enrollment in excess of 27,500 by the middle of the next century.

A Review of “Conventional” Fiber Optic Technology at UCR:

In 1990 the University determined that fiber optic cabling was becoming essential throughout much of the campus. Primarily, data communications were the immediate concern. However, there was also growing interest in a variety of other potential applications including a distributed telephone system, video, security, and facilities management systems.

In response to the growing need for high speed data support work began to construct the initial segments of a fiber backbone. This would be used to replace an existing broadband copper backbone. Planning the fiber backbone would be a difficult task. The requirements for data support were expanding quickly and constantly changing. The rapid pace and potential disruptions that could be caused by the large number of major construction projects were another concern. Also, the limited routing infrastructure resulting from a Campus dating back a half a century was proving to be a major obstacle.

Initially, the University determined that 48-strand, 62.5/125 micron, multimode cables installed in a (serial) bus topology would best support the requirements for data. In the bus topology, cables were installed from a centralized data hub (located in the Statistics and Computing Building) serially to other key buildings requiring high speed data support. As the cable passed through each building, strands could be dropped (for use in that building) or patched-through (to support down-stream destinations). By 1991, a total of 13 buildings were connected to the backbone. Almost immediately, numerous problems developed:

1. The total number of strands selected were insufficient to keep pace with the rapid expansion of data applications (primarily caused by the exploding trend in the number of LAN connections that were being required).

2. The aggregate signal loss (dB loss) was reaching the budget limits due to the large number of serial segments and the corresponding patching requirements.

3. The number of problems were increasing with each new segment. These were also getting increasingly difficult to diagnose and repair. Most problems were primarily of an intermittent nature and difficult to diagnose through the multiple segments. Many strands had to be abandoned altogether.

4. Major construction projects jeopardized many of the available cable routes. While alternative routes could be provided as an outcome of the construction projects, the interim periods would clearly put the initial routes in jeopardy.

5. The emergence of additional fiber applications were indicating that other types of cable media might be needed (singlemode). These new systems appeared to be more demanding in all areas of cable performance. Most importantly, they could require entirely different topologies (a different central hub point and remote end points).

With the adoption of a new Long Range Development Plan in 1991, many Campus improvements were ready for implementation. Included in LRDP was a project aimed at providing a new Campus-wide fiber backbone. This project would serve as a convenient opportunity to upgrade and/or replace the existing backbone leaving the many problems of the existing system behind.

The proposed LRDP fiber backbone system featured a design with all of the "conventional " industry wisdom. It utilized a "hierarchical star" topology, as many as three or four cable segments deep. The central hub point would remain in the Statistics and Computing Building. From there, large count, composite cables (typically containing a minimum of 48-strands of multimode and 24-strands of singlemode) would be installed to secondary hubs. This made-up the first layer in the system's hierarchy. Through patching or splicing, these "first layer" cables would be connected to cables routed to other buildings (making-up the second layer of the hierarchy). A third or fourth layer would also be added until all Campus buildings were ultimately connected. Within each building, additional layers of cabling would also be added to the network to support distribution to the various internal telecommunication closets.

While the proposed LRDP system design did provide many significant improvements (when compared to the initial fiber backbone already deployed), there were still numerous concerns that were difficult for this new system to resolve:

1. The design had no provisions for diverse routing (parallel routes). With the large amount of construction occurring on Campus over the next decade, the system would be extremely vulnerable to a significant outage. The relatively high costs to build the system and limited amount of routing infrastructure would make it exceedingly costly to provide diverse routing and make the system more fault tolerant.

2. Careful evaluation of new fiber-based applications confirmed that more than one centralized hub point might be required. Essentially, each new application required a different central connecting point with a large amount of fiber distribution required to reach the rest of the campus. Virtually none of these new hubs were located physically close to the Statistics and Computing Building and typically resided in the lower layers of the proposed system hierarchy (where a very limited amount of capacity was available). An additional concern dealt with the fact that several of these locations could be moved during the course of the ongoing major construction projects. What's more, each new application carried a unique set of fiber optic cable performance criteria. It was hard to determine exactly what performance values were to be expected over the longer term.

   The University concluded that if the proposed LRDP design were built, major retrofits would be needed in order to cope with these new applications.

3. The proposed design did not seem to alleviate the obstacles associated with problem diagnosis and repair. Generally speaking, the layered hierarchical star topology tended to reduce the total number of interconnects required to get to the remote end points (when compared with the existing serial bus topology). On the surface, this seemed like a big a plus. However, the combined effects of the multi-layered backbone approach combined with the additional layers used for intra-building distribution significantly took from these gains. Further, the large number of total strands to be installed, inclusion of multiple types of media (multimode and singlemode), and the large-scale use of both splicing and patching technologies clearly indicated that overall network management would be as difficult as in the past.

Regardless of these concerns, the communications demands of the University required that the proposed LRDP fiber backbone expansion project would have to commence by 1992 and be completed in 1993. There simply appeared to be no other option.

As a preliminary project planning efforts began, studies were undertaken by the UCR Telecommunications Department to determine the overall project budget and implementation strategy. Financial data was compiled using a number of resources including; vendors, outside consultants, information gathered from other major Universities, and historical data gained from the previous fiber projects at UCR. Implementation strategies were designed to coordinate with routing improvements and possible cable damage that could occur as a result of the many major construction projects that were being planned or underway.

A preliminary project budget including initial (Year-1) deployment cost and longer term (5-year) operational costs and upgrades were tallied. The total five-year budget was $3,813,000. The following pages provide brief summary of these costs.

Conventional Fiber Deployment Budget Summary

Year - 1

Initial Deployment and First Year Operational Costs

1. Fiber Optic Cable Installation, Termination, Testing, and Documentation	$ 2,088,000.00
2. Conduit and Other Cable Routing Improvements	$ 300,000.00
3. System Upgrades Resulting From New Construction Projects or New Applications	$ 100,000.00
4. Personnel, Ancillary Equipment, and Other Operational Costs	$ 75,000.00
5. Reserves for Problems and Other Contingencies	$ 50,000.00
Total Year-1 Costs	$ 2,613,000.00

Year - 2 Thru -5

Annual Costs Resulting From New Construction Projects and System Operational Costs

1. System Upgrades Resulting From New Construction Projects or New Applications	$ 200,000.00
2. Personnel, Ancillary Equipment, and Other Operational Costs	$ 50,000.00
3. Reserves for Problems and Other Contingencies	$ 50,000.00
Total Annual Costs	$ 300,000.00
Total Five Year Costs	$ 3,813,000.00

Introduction of Air-Blown Fiber Optic Technology at UCR:

In December of 1992 (about the same time as the University was completing the budget process for the new LRDP fiber backbone project) the University's Director of Telecommunications was invited to a presentation on the FutureFlex Air-Blown Fiber Optic Cabling System (ABF).

Immediately, several significant advantages were recognized by the Director:

1. Overall project costs could potentially be significantly reduced.
2. The entire system could be built using point-to-point cables (requiring no patching or splicing). This could provide a major improvement in overall system reliability, administrative needs, and provide the very optimum in all areas of cable performance criteria.
3. The system could be built incrementally, with small count cables being deployed initially and expanded when, and if, they were needed. Major design issues and capital investments could be deferred until actual needs materialized.
4. Future additions (expansion) could be made quickly without disruption, and with virtually no financial penalty.
5. The compact size of the system could possibly fit within the existing conduit system. In addition to removing significant costs from the project, this would eliminate many disruptions to Campus-life caused by the trenching and digging associated with adding a new conduits system. Additionally, the project could move ahead following a very aggressive schedule without being impacted by the coordination with other major construction projects.

6. The problems associated with supporting new fiber applications would also be solved. The ABF system could support multiple topologies simultaneously. In fact, the system would not have a specific topology. The overall topology of the system would simply be the result of each new cable to be added. Both the centralized hub points and remote end points could be located anywhere on Campus.

7. The system provided a practical method for a diverse cable routing scheme. Additionally, cables could easily be re-routed at anytime to avoid potential conflicts with the major construction projects.

8. Problem/disaster recovery capabilities of the system appeared to be truly remarkable. The patented "cable blowing" process ensured that new cables could be installed, or damaged cables replaced literally in minutes. Added to this was the fact that vendor presenting the ABF system (AIDCO, Inc.) offered a guaranteed 4-hour (half-day) response time commitment for all new cable requests.

Following the ABF presentation, the University developed a very strong initial interest. However, this interest being tempered by a need to move quickly. New fiber was already needed in several critical locations. In response, the University's Director of Telecommunications moved quickly to further evaluate this new alternative. He immediately arranged to visit the University of Utah and meet with key network planning and implementation staff. Utah was the “flagship” beta-test site for ABF in the United States. Initial ABF installation began in Utah in 1991 and had grown very rapidly to include a vast fiber network already supporting a myriad of sophisticated applications. The trip was very productive and added to enthusiasm stemming from the initial ABF presentation.

In order to keep pace with the Campus needs, and provide a method for further evaluation of ABF, the University's Telecommunications Department decided to bid the first few segments of the new fiber backbone. These bids would include AIDCO (bidding ABF) pitted against other vendors (bidding conventional fiber). This process would allow the University to determine if the economic advantages of ABF were substantive. And if proven economical, it would also allow the University an opportunity to conduct a hands-on "pilot test program" and further analyze the other issues and/or benefits. During this pilot test process a total of five (5) cable segments were put to bid. Clearly, the ABF system was found to be the most economical alternative. In all five bids, ABF came in at substantially lower costs. The total of the five ABF bids was $76,906 while the lowest of the conventional bids totaled $135,271. This resulted in a savings of approximately 44%.

Encouraged by the economic issues, the specific nature of these first five pilot projects provided an excellent test-bed for additional evaluation of the ABF segments.

The selected routes were:

- Both the closest and most distant of Campus destinations (long and short routes).
- Most of the conduits supporting these routes were of limited size, very old, and were populated with a wide-variety of other types of cable.

As promised, the ABF installation was completed ahead of schedule and with no significant problems. Many staff members observed all aspects of the installation. They paid especially close attention as each new ABF cable was installed (blown-in) in a few minutes. Analysis of OTDR and other test results revealed that the patented "stress-free" air-blown method of installation was consistently yielding perfect test results.

Additional blowing demonstrations by AIDCO provided a practical illustration of the ease in which cables could be blown-in or out, re-routed or relocated, and used over and again. On all fronts, ABF technology was proving itself against conventional fiber during the pilot test program.

Before making a full-scale commitment to this new fiber alternative, the University wanted to confirm other key issues. While the economics and basic technology were impressive, there were many other issues that warranted additional investigation (primarily of a business nature). The following listing summarizes these concerns and the conclusions drawn by the UCR staff during a continued investigation:

1. *Manufacturer Credibility and Commitment:*

This line of investigation led UCR to the following conclusions. FutureFlex® ABF is manufactured in the United States by Sumitomo Electric Lightwave (S.E.L.). S.E.L. is an industry leader and one of the three (3) largest manufacturers of fiber optic cable world-wide. Combined annual revenues of the S.E.L. Parent Corporation exceed $280 billion. And more than 95% of the products making up the ABF system are made in the U.S. with excellent production capacity in-place and more than adequate on-hand stocking available locally.

2. *Credibility of The Technology:*

In addition to the first-hand evaluation opportunities gained from the UCR pilot program, the system had previously been installed in many other prestigious locations nationwide. While seemingly new to the U.S. market, other countries (including the UK, other European Countries, and Japan) had been using ABF technology for nearly a decade.

3. Access and Availability of Training, Experienced Installation Vendors, and Local Inventory:

The University learned that ABF is a patented, and proprietary technology. Many aspects of the system are carefully safeguarded by the Manufacturer to avoid intrusion by other potential Manufacturers.

The system is supported by a mature and thorough factory-sponsored training program. Owing to the unique system design concepts and installation methods, S.E.L. requires that the system only be designed and installed by a fully trained and qualified resource. ABF system designs are often a wide departure from the designs that accompany conventional fiber systems. Knowledge of the conventional fiber industry does not adequately qualify an ABF system designer/installer. Without the additional training provided in the S.E.L. program, many of the benefits of ABF technology could be lost by an improperly trained resource. As a matter of practicality, end-users may choose to have any design or installation resource (or combination of resources) trained by S.E.L. or select one from the network of existing authorized installers.

Similarly, controlled access to product provides an additional safeguard. ABF products are not available through normal channels of distribution (and hence, available to anyone that wants to buy it). Instead, products may be purchased directly from S.E.L. or via the network of authorized installers. Nearly all materials are available locally, and on a next-day basis.

4. Evaluation of Comments From Competitors:

Several Manufacturers provided comments (or papers) focusing on ABF technology. Essentially, all of these comments were very shallow. Virtually none of the concerns raised were of a substantive nature. Instead, they tended to address issues that made it clear that the possible loss of market share was their main concern.

With the all of the positive information achieved from the pilot test program and additional investigative activities, the next step in the evaluation process was aimed at understanding the implications of ABF in a large-scale application. AIDCO was asked to prepare several ABF system design models and corresponding project budget information for a system that would replace the pending LRDP “conventional fiber project”. Quickly, AIDCO conducted an extensive survey of the existing campus routing infrastructure and other design issues. They responded with wide-range of system options. Primarily, these options provided a choice of how the "tube cable" sub-system would be designed and constructed.

The University quickly discovered that selecting a tube cable sub-system would be the most significant ABF design decision. Tube cable is a specialized routing vehicle used exclusively with ABF. In application, it provides many of the same functions as the inner-duct typically used with conventional fiber. However, tube cable is very small in contrast to inner-duct. Each tube cable cell is approximately 1/4" in diameter compared to inner-duct which typically ranges from 1" to 2" in diameter. Additionally, tube cable could be provided in assemblies that packaged multiple cells under a common protective sheath. The University could select 2, 7, or 19-cell tube cables (or even multiple tube cable assemblies) for each of the fiber optic cable routes.

It finally turned out that design decisions regarding the tube cable sub-system were going to be easy to make. The overall ABF system costs proposed by AIDCO were far below the most hopeful expectations of the University. Tube cable was proving not only very economical to purchase, but the corresponding installation costs were fairly constant regardless of what size tube cable (the number of internal cells) would be selected. Essentially, installing a very large tube cable (or multiple tube cables) is as easy as installing a smaller one. Moreover, the compact size of the tube cables was making it very clear that the limited routing capacity of the existing conduit infrastructure was not going to be an issue. AIDCO's survey revealed that even the largest tube cable design models would fit within the existing conduit and other routing infrastructure. Little or no additional conduits would be required with any of the proposed design models.

With all of these savings at hand and the routing obstacles removed, the University selected a large tube cable sub-system design. The selected model would utilize less than 10% of the tube cable system when populated with all of the known fiber requirements. This would leave the remaining 90% as surplus capacity to be used for long-term system growth. Moreover, the selected system would also feature a diverse routing capability by sub-dividing the Campus into a series of interconnected tube cable "rings".

In contrast to the tube cable decision, determining the amount of fiber optic cable that was going to be installed initially was extremely easy. With ABF, all of the incentives to install more cables (or "glass") than were actually needed were removed. The concept of "future-proofing" the network with a large number of cables containing multiple types of media, and plenty of extra strands (typically done with conventional fiber) was eliminated altogether. Using the patented air-blown installation process, the costs for installing a cable today vs. the costs for installing it later were a "constant". And it should also be noted that at $168 per-cable (proposed by AIDCO), the installation costs were indeed very small. In the end, the number of the cables that were to be initially installed, and their size (within customary industry increments of six), equaled the exact number that were needed at the time and nothing more.

Moving ahead with a large-scale ABF deployment project seemed the most prudent option. In September 1993, the Purchasing Department solicited bids from locally-based authorized ABF system installers. The bids were based on the survey data and the design submissions of AIDCO. The tube cable system would initially reach approximately 70% of the campus buildings and met the 10% initial fill, and 90% additional (surplus) growth capacity goals previously established.

The selected vendor (again AIDCO) completed the project in a total elapsed time of four (4) months, well ahead of the University’s one-year schedule. By February 1994, most of the ABF fiber network was already placed into full operation. At this time the total cumulative ABF system deployment costs were less than $380,000 (including the first five pilot projects). Essentially, the system fit within all of the existing conduits and other routing systems as promised. In all, a total of $650 in conduit upgrades were all that were required.

The listing (provided on the following page) more specifically identifies the overall scope of the ABF system as of January 1994 with the pilot projects and the major deployment project completed:

UCR ABF SYSTEM STATISTICS
(Through 1-1-94)

TUBE CABLE SUB-SYSTEM

Tube Cable Segments Installed	58
Tube Cable Feet Installed (Assemblies)	21,115'
Tube Cable Feet Installed (Cells)	255,850'
Tube Cable Feet Occupied (Cells)	18,325'
Tube Cable Feet Empty (Cells)	137,525'

FIBER OPTIC CABLES

Fiber Optic Cables Installed	22
Fiber Optic Cable Feet Installed	18,325'
Fiber Optic Cable Strands Installed	132
Fiber Optic Cable Strand Feet Installed	109,950'

Continued Deployment of Air-Blown Fiber Optic Technology at UCR:

From January 1994 to January 1996, UCR has expanded the ABF system to include all but two (2) of the remaining Campus buildings (these have been left out as they are still being supported by the original conventional fiber network).

In addition, the system has been expanded to:

- Support a number of new buildings that have been completed
- Keep pace with the rapid expansion of data (LAN) applications
- Support the installation of a new distributed telephone system

In all, this expansion has been significant. Through all of this, the results of continued ABF deployment have been equally impressive:

- The number of fiber optic cables installed during this two year period has increased from 22 to 72 (more than 300% growth). Despite this, the 90% surplus growth capacity goals for the tube cable system are still very close to being met.
- Most impressive is that fact the total accumulated ABF system costs through January 1996 have reached $692,000. This is in stark contrast compared to $3,513,000 in expenditures that were forecasted for the original conventional system through this same period. Savings for the first five-year period are expected to be approximately 75%. Moreover, this cost saving trend is expected to continue over much longer period (10 - 20 years).
- Also impressive is the fact that during the entire period that ABF has been installed, there has not been a single outage or failure of any sort. The combined benefits of a point-to-point system architecture and inherent mechanical integrity of the system have been field proven in a very demanding environment.

- Service delivery has also been excellent. All required materials have been readily available. Response time commitments for all installation requests have been consistently met by the vendor. Timely and accurate as-built documentation has also been delivered with each successive addition.

Conclusions Drawn From Air-Blown Fiber Optic Technology at UCR:

Many important conclusions may be drawn from the history of ABF technology at UCR . These conclusions are essentially a matter of historical record and evidenced through first-hand observation and analysis. They may be summed-up by the following conclusions:

- When compared with conventional fiber alternatives, the selection of ABF technology has produced substantial cost savings in the 70% to 75% range.

- ABF system reliability has been perfect. With no failures to date, the existing large-scale ABF system has performed superbly especially when compared with frequent failures that were occurring in the much smaller "conventional" fiber network.

- The simplified point-to-point system architecture, elimination of nearly all patching, and accurate as-built documentation have reduced system management and administration requirements and associated costs to the absolute minimum levels.

- All ABF system expansion costs are highly predictable and provide a timely and accurate mechanism for evaluating and allocating all new additions. With an ABF tube cable system already in place, all of the uncertainties about cable routing are eliminated. In contrast, an extensive analysis process (or bidding process) has traditionally been required in order to predict the costs for adding or changing conventional fiber optic cables.

- The prompt response for all new ABF installation requests has substantially improved the service delivery capabilities of the UCR Telecommunications Department. The ability to rapidly add or change the ABF cabling is unmatched by conventional fiber. ABF cables may be added or relocated in minutes. Conventional fiber optic cables are were added in days, weeks, or months. And the notion of relocating one was regarded as an impractical or impossible task.