TABLE 2-1
SYSTEM PROFILES SUMMARY SHEET

FEATURE	GAFFNEY	GEORGETOWN*	GREENWOOD	ORANGEBURG
CABLE LENGTH (feet) / FIBER COUNT	62,832 / 12 108,000 / 96*	63,877 / 60 19,968 / 24 37, 613 / 12 37,065 / 6	93,599 / 48 108,984 / 36 21,400 / 24 12,126 / 8	15,000 / 30 27,000 / 24 85,600 / 18 86,600 / 6
TOTAL CABLE LENGTH (feet)	170,832	158,523	223,943	214,600
TYPE CONSTRUCTION	ADSS on Distribution Poles	ADSS on Distribution Poles ALT in Duct	ADSS on Distribution Poles ALT in Gas Pipe ADSS in Duct	Messenger Supported Lashed ADSS on Distribution Poles*
PHYSICAL TOPOLOGY	Radial (Existing) Ring*	Ring With Collapsed Ring Extensions	Ring With Collapsed Ring Extensions	Radial Two Interconnecting Rings*
LOGICAL TOPOLOGY	Radial Self Healing Ring Under Evaluation	Self Healing Rings	Self Healing Rings	Radial Self Healing Rings*
TECHNOLOGY DEPLOYED	1200 Baud Audio Modems 10 MB Ethernet	Token Ring Type SCADA Ring OC-3	Token Ring Type SCADA Ring 310 MB ATM	SCADA 10 MB & 100 MB Ethernet RS 232 PBX OC 3 / OC 12 *
UTILITY USES	SCADA	SCADA LAN / WAN Voice	SCADA LAN / WAN Voice	SCADA LAN / WAN Voice
NON-UTILITY USES	None to Date	None to date	2 Fibers leased to Piedmont Technical College, with an option for 2 more; used for RF video system. 2 Fibers leased to District 50 Schools for WAN.	Eight miles of 6 fiber cable leased to SCANNA-NET.
STAFF	One at ¼ time One at ½ time	None Planned	One at ½ time	One at ½ time
REVENUE	None	None	Two Fibers for $2,200 per month (4 sites) Two Fibers for $8,500 per month (17 sites)	$400 - $500 per month from SCANNA-NET

* Under construction

station and the four RTUs. The optical electronics are 1,200 baud audio modems manufactured by Math Associates.

The 1992 expansion maintained the same cable type, fiber type and count, pole line construction and hardware, logical topology, and optical electronics. This expansion included 46,632 feet of cable.

2.1.3 Proposed System/Expansions

Gaffney is currently installing a ring around the perimeter of the BPW electric service area. The cable, which is 96 fiber, single mode ADSS, is manufactured by Lucent Technologies. The ring will include about 108,000 feet of cable. BPW crews will install the cable in the supply space of the BPW's 25 kV distribution lines. Preformed Line Products will supply the pole hardware.

2.1.4 Utility Functions

The existing BPW fiber system is the primary communication medium for the SCADA system (two RTUs communicate by leased phone lines). RTUs located at each of the four substations and at the five standby/peak shaving units are linked to the master station at the Operations Center by fiber optic modems. Additionally, the BPW uses the fiber system to extend the SCADA master station 10 Mbps Ethernet LAN from the Operations Center to the remote operator station at the WTP.

2.1.5 Non-Utility Functions

At present the BPW does not use the fiber system to provide any non-utility communications.

2.1.6 Staff

With the exception of some temperature related modem failures, the BPW fiber system has operated virtually trouble free since the initial installation in 1991. Because the fiber system requires little or no daily attention, the BPW has not added any full time staff to work with the system. The supervisor of the SCADA system oversees the fiber system.

During the design and construction phase of the 96 fiber ring project, the SCADA superintendent is spending about 10 hours a week on the project and his assistant is spending about 20 hours per week. When the 96 fiber ring is complete, the BPW anticipates one staff person devoting about one-quarter time to the fiber system.

2.1.7 Revenue

The BPW has does not currently receive any revenue from its fiber optic system.

2.2 Georgetown

The City of Georgetown, SC owns and operates the Utilities and Public Works Department which provides water, sewer, and electric service to the citizens of Georgetown (the same department also

maintains the storm sewer system and runs the Streets/Sanitation Division). The City serves about 5,000 electric and water customers.

2.2.1 Background

In 1997, the City commissioned UTEC to study and evaluate the technical and economic feasibility of the City installing a fiber optic ring to provide optical communications to each of the Utilities and Public Works Department's facilities. Based on the results of that study, the City held a referendum where voters were asked to approve the City's construction of a fiber optic utility. The referendum, held in February of 1998, passed with an overwhelming margin. After the referendum, UTEC completed the design and prepared specifications for the system. The City concurrently advertised for letters of interest from prospective bidders to furnish, install, and maintain the system.

The City received letters of interest from two prospective bidders, GTE and HTCC (a subsidiary of Horry Telephone Cooperative). UTEC and the City staff interviewed representatives from both companies. Based on a recommendation from UTEC and the staff, the City Council voted to negotiate a contract with HTCC. HTCC and UTEC negotiated a contract price, which the staff presented to the City Council on June 18, 1998. The Council approved the contract and construction is scheduled to begin in July of 1998.

2.2.2 Existing Physical Plant

Georgetown does not currently have any fiber optic facilities. The existing SCADA systems (one for the water facilities and one for the electric system) use multiple address radios and leased phone lines.

2.2.3 Proposed System/Expansions

The proposed system includes a twelve mile, 60 fiber backbone ring with over 18 miles of branches off the main ring. The system will extend to over 40 remote sites, including almost 30 SCADA remotes. All of the fiber will be single mode. Most of the cable will be ADSS installed on City-owned distribution poles in the supply space. About 22,000 feet of cable will be armored loose tube (ALT) installed in duct on DOT right-of-ways. HTCC is supplying all the materials, installing the cable, and splicing and terminating the fibers. The City will provide building penetrations.

Each fiber of the main ring will terminate at both the electric operations center and at HTC's fiber POP (point of presence) in Georgetown. This will allow connectivity for any fiber on the ring to the public telephone network and the world wide web (this type of connectivity is euphemistically referred to as a connection to the *world* in this report).

The contract with HTCC specifies that HTCC will operate and maintain the system for an annual fee.

2.2.4 Utility Functions

The proposed fiber system will provide optical communications to 29 water, waste water, and electric remote sites for SCADA communications. The system will also provide a ring for a computer network to link City Hall, the electric operations center, the water plant, public works, and the waste water plant.

The City is also evaluating using the system for a new voice communication system. HTCC is proposing to install optical electronics in City facilities to link City offices to the *world* through HTC's POP in Georgetown.

Georgetown is also evaluating the benefits of using the high bandwidth fiber connection to set up a Georgetown web site on an HTCC server; a type of electronic community center.

2.2.5 Non-Utility Functions

In addition to the construction and maintenance contract with HTCC, the City is also negotiating a contract with HTCC where HTCC would market the City's spare fibers to institutional and commercial users. Under this agreement, Georgetown will receive a percentage of the revenue from HTCC for each user. HTCC will have end-to-end responsibility for the fiber, including supplying and maintaining any optical electronics. HTCC is proposing to set-up and staff a retail office in Georgetown.

2.2.6 Staff

Since the construction contract and the proposed marketing contracts with HTCC include maintenance of the physical plant, marketing of the spare fiber, and end-to-end customer service, Georgetown does not anticipate adding any additional staff.

2.2.7 Revenue

The Georgetown fiber system is under construction, and therefor the city does not currently receive any revenue form the system.

2.3 Greenwood

Since 1896 the Commissioners of Public Works (CPW) has provided utility services to the citizens of Greenwood, SC. The CPW has 12,473 electric meters, 17,929 water meters, and 16,405 gas meters for a combined total of 25,336 customers.

2.3.1 Background

In 1994, UTEC designed a SCADA system for the CPW's electric and the gas systems. At the CPW's direction, UTEC designed the system based on fiber optics for the RTU/master stations communications. As part of the design process, UTEC evaluated the cost of a CPW owned fiber optic system compared to the cost of fiber optic communications provided by the local telephone company. UTEC defined a scope of fiber topology that included a logical and physical ring with connections to six RTU sites, the Commission Main Office (CMO) and the Central Operations Center (COC). The local telephone company, Sprint United, submitted a proposed contract that included a minimum five year term at over $8,000 per month for eight fibers. Sprint United also proposed that the agreement would include a limited use provision (the CPW would agree to use the fiber for SCADA functions only). UTEC estimated that the CPW could build their own network for less than the net present worth (NPW) of the

five years of payments to Sprint United. UTEC estimated the NPW of the payments to Sprint United at more than $400,000.

The Commissioners voted, in essence, to build a fiber network, with as much capacity as possible, without exceeding the net present worth of what the sum of payments to Sprint United would be under their proposal. UTEC estimated the CPW could easily build a 36 fiber ring for less than $400,000. The Commissioners, based on additional estimates and input from the staff, approved construction of a 48 fiber ring. The final cost of the system, including cable, hardware, splicing and terminations, equipment rental, and contractor charges was $310,021.

The CPW has completed three major expansions to the system. In 1996, the CPW received a request from a local college to provide fiber connections between the college, two high schools and a local university. In 1997, the CPW expanded the system again to provide fiber connections for a jointly owned phone system to CPW, City, and County facilities. In 1997, in response to a Request for Proposal from the Distinct 50 Schools, the CPW submitted a proposal, and was awarded a contract to link the 16 campuses and the central office with a fiber optic ring.

2.3.2 Existing Physical Plant

The original CPW installation was a 16 mile, 48 fiber, single mode physical ring, with about 2.3 miles of eight fiber radial taps to RTUs. The cable was primarily ADSS installed on CPW distribution poles. About 8,000 feet of the 48 fiber ring was armored loose tube cable installed underground in 2 inch gas pipe. Alcoa Fujikura Limited (AFL) supplied the cable, and the tangent assemblies. Preformed Line Products supplied the dead end assemblies. CPW crews installed the cable. AFL supplied splicing, termination, and testing services.

The first expansion included 8,333 feet of 48 fiber and 17,600 feet of 24 fiber ADSS cable. This expansion extended the ring to Piedmont Technical College, Lander University, Greenwood High School, and Emerald High School. Chromatic Technologies supplied the cable for this expansion. Dulmison supplied the pole hardware. As with the original ring, CPW crews installed the cable.

The second expansion was to provide fiber optic links between a PBX and remote sites for a joint city, county, and CPW phone project. This expansion included about 4,000 feet of 24 fiber cable, installed primarily in underground conduits in the downtown area.

The third expansion was to link the 16 campuses of the District 50 schools with the District 50 central office. Most of the sites were within or near the existing 48 fiber ring. However, one school, Hodges Elementary, was almost 7 miles outside the ring. The project added over 21 miles of fiber to the system, nearly doubling the size of the system. Three major portions of the project were installed by a contractor in underground duct. As part of this project, the CPW extended the fiber ring to its Lake Plant water treatment facility.

2.3.3 Proposed System/Expansions

At this time the CPW has no announced plans to expand the system.

2.3.4 Utility Functions

The CPW uses the fiber system for the following functions:

- A self-healing ring for SCADA communications with five electric substation RTUs, one gas regulator station RTU, one electric generator RTU, and two gas pressure sensor RTUs (under construction).
- A remote operator station at the Lake Plant water treatment facility (under construction).
- A self-healing 310 Mbps ATM network that links the following computer resources:
    - The CPW business computer (IBM AS 400) and remote work-order terminals and printers.
    - The CPW GIS computer (IBM RS 6000) with links to the GIS computers for other agencies.
    - The CPW SCADA Master Station (Dual HP work stations).
    - 35 plus PCs operating on a Windows NT network.
- Radial links to four remote equipment shelves for a shared Nortel 81C PBX.

2.3.5 Non-Utility Functions

The CPW currently leases two fibers on the ring, with an option for two more, to Piedmont Technical College (PTC). PTC uses the fiber for remote video links to Lander University, Greenwood High School, and Emerald High School. The CPW also has a contract to provide a two fiber logical ring to the 16 schools and central office of the District 50 Schools.

2.3.6 Staff

The CPW has not added any new staff positions as a result of the fiber system; however, the substation supervisor spends about one-half of his time on fiber related work.

2.3.7 Revenue

The CPW currently leases two fibers to PTC with and option for two more. PTC pays the CPW $2,200 per month for two fibers terminated at four sites. The CPW has also completed construction on a project for the District 50 Schools. District 50 will lease two fiber on the ring, terminated at 17 locations for $102,000 per year. The contract also included an installation fee of ($183,947 or $146,101) and includes an annual maintenance fee of ($20,400 or $47,784).

2.4 Orangeburg

Orangeburg Department of Public Utilities (DPU) is South Carolina's largest municipal utility with a service territory of 340 square miles. The DPU has over 33,000 services (including security lights) and 22,400 customers.

2.4.1 Background

The DPU first installed fiber optic cable in 1988 as a communications media for the DPU's SCADA system. The DPU had once planned to use the system in conjunction with a municipal cable TV system. The local cable provider challenged the DPU's authority to provide cable TV service. The case, which went all the way to the SC Supreme Court, was decided in favor of the cable company.

2.4.2 Existing Physical Plant

The DPU system includes over 43 miles of fiber optic cable. The system includes 6, 18, 24, and 30 fiber cable. Most of the system, 40 miles, is messenger supported lashed cable. The DPU recently installed 24,000 feet of ADSS cable. The system extends from the DPU office radially on five main branches and terminates in 22 remote sites. The DPU has purchased cable from several vendors including Siecor, Pirelli, and Fujitsu. The optical electronics used by the DPU includes Harris T-1 multiplexers, 10 and 100 MB Ethernet networks, H&L Instruments transceivers, and Dymec RS-232 extenders.

2.4.3 Proposed System/Expansions

The DPU's current expansion will create two interconnecting rings. The electronics will be scaleable OC3 or OC12.

2.4.4 Utility Functions

The DPU uses the fiber for the following functions:

- Voice communications using a PBX.
- Data over a 10 and a 100 MB Ethernet LAN/WAN to four remote sites including the following:
  - Water Treatment Plant
  - Waste Water Treatment Plant
  - Maintenance Shop
  - Warehouse
- RS-232 connection to a remote SCADA operator station.
- SCADA communications with 30 RTUs.

2.4.5 Non-Utility Functions

The DPU leases about eight miles of six fiber cable to SCANNA-NET. SCANNA-NET uses the fiber for telecommunications.

2.4.6 Staff

The DPU employs one technician who devotes about ½ time to the fiber system.

2.4.7 Revenue

The SCANNA-NET lease is usage sensitive and generates about $400 to $500 of revenue per month.

3. FUTURE OF FIBER

As the graph in Figure 1 illustrates, telecommunications traffic is expected to increase dramatically. Telecommunications providers are spending billions on infrastructure to meet the demand. A recent trade journal reported the following information on the growth of fiber systems[3]:

- Local Exchange Carriers (LEC) increased installation of kilometers of fiber 23.4% from 1995 to 1996.
- Competitive Access Providers (CAP) installed 975,000 kilometers (604,500 miles) of fiber in 1997.
- Cable Television Companies installed 3,400,000 kilometers (2,100,00 miles) of fiber in 1997 (more than the Bell Companies).

In addition to building more infrastructure, carriers are working to push more traffic through existing fibers. Sprint installed equipment in April that will allow the carrier to increase its network capacity by 600 percent[4]. Clearly, the long distance carriers, the cable companies, the LECs, the CAPs, and the Competitive LECs believe fiber is a good investment. Is fiber a good investment for members of SCAMPS? This section is a brief discussion of some of the variables that could impact the decision to install fiber. These variables include the following:

- Technology - Is fiber the technology of the future, will it be supplanted by other technologies?
- Competition - Will other providers be able to offer a better product?
- Regulation - Will regulators allow municipals to provide fiber services?

3.1 Technology

Single mode fiber, the type installed in each of the cities in this report, has an unlimited bandwidth. The amount of information that can be transmitted over one fiber is limited by the electronics at the ends. Sprint has installed a system that can transmit over 3 million phone calls over two fibers [5]. No other technology can come close. Additionally, the new electronics are compatible with existing fiber. The same fibers Gaffney installed in 1990 to transmit a 1,200 baud analog signal could be used in Sprint's OC 48, 96 channel Wavelength Division Multiplexing System which operates at 238.87 Gbps. Fiber's superior capacity and its ability to work with new technologies establish it as the technology of choice for telecommunications; however, fiber does have competition.

---

[3] Michael Fahey, "Outside Plant Forecast", CABLE FOREMAN, April 1998, pp12 - 13.
[4] Michael Fahey, "WDM Boosts Fiber Optic Capacity", CABLE FOREMAN, May 1998, p 6.
[5] Ibid.

One obvious limitation of fiber is that it is a site specific solution; that is the fiber must physically extend to the user, and to another user, or the *world.* Communications systems based on satellite technology do not have that limitation. Over the next two years, four different groups will spend over $12 billion to installed four competing global satellite systems. One system, *Iridium,* is ready to begin operation on September 23, 1998. While satellite systems provide world wide mobile coverage, the data rates are low. The Iridium system offers voice, paging, and 2,400 bps data services. Each of the 72 Iridium satellites can handle 1,100 simultaneous duplex calls[6] (or about ½ of the capacity of Orangeburg's proposed OC-3 system).

Satellite systems are not designed to provide the high bandwidth available from fiber optics. To fixed site users with high data rate requirements, satellite technology does not compete with fiber. One exception is remote areas where fiber is not accessible.

The inherent advantage that municipal systems have is right-of-way and the ability to extend the physical media to a customer's site. If a municipal can connect a high bandwidth user to another user, or to the *world,* then they are in position to make fiber work.

There are obviously many other communication technologies beside fiber and satellites including the following:

- Twisted pair
- Cable modems
- Wireless microwave subscriber lines
- Cellular phones
- Power line carrier Internet connections[7]

It is beyond the scope of this report to analyze the merits of these technologies. They are listed simply to remind the utility manager to evaluate their needs and the need of any potential customers, and compare those needs to the wide variety of technologies available. Installing fiber, just because it is the best technology, may not be wise. The technology should match the need and be cost effective.

3.2 Competition

Based on UTEC's experience over the last 10 years, competition to provide fiber optic communications is everywhere. One contractor reported to UTEC that a customer installed a four duct system around a NC city as a speculative venture. Before the project was completed, the duct owner had leased one inter-duct to a CAP who was going to install a fiber loop around the city. The lease for that one duct

---

[6] Barry Miller, "Satellites Free the Mobile Phone", IEEE Spectrum, March 1998, Volume 35, Number 3.
[7] Karen Graziano, Cabling Installation and Maintenance, March 1998, as quoted in "Promoting Internet access over power lines", CABLE FOREMAN, June, 1998, p. 12.

paid for the entire project. That anecdote illustrates the aggressive nature of investors in the fiber business; that someone would install duct on the hope that someone would lease it for fiber. Once again, the many issues in this subject are beyond the scope of this paper. The caution UTEC would offer to the utility manager who is considering installing fiber is that if there is a market, and if there are potential customers, there likely will be competition .

3.3 Regulation

As is well known, the SC Supreme Court's ruling put a stop to Orangeburg's plans to use its fiber system to offer cable TV service. In Greenwood, Sprint United has an open filing before the Public Service Commission objecting to the CPW's contract with Piedmont Technical College. A brief summary of the status of the regulatory environment as it relates to municipal fiber systems is: we know some of what we can't do, but we don't know what we can do. UTEC can make no recommendations regarding what utilities can legally do or cannot do.

4. SUMMARY

In summary, UTEC offers the following observations:

- Fiber optics offer the best technical solution for SCADA and relaying applications.
- Fiber will likely cost more than other alternatives, such as radio or leased phone lines.
- Fiber is extremely reliable.
- A fiber system will not significantly increase staff requirements.
- Municipal Systems can build fiber with their own crews with minimal training.
- Fiber will continue to be the technology of choice for high bandwidth, fixed site installations.
- Fiber is not as subject to obsolesce as many other technologies.
- There will be competition for customers.
- The regulatory/legal environment is uncertain.

APPENDIX A

APPENDIX A

	Case 1	Case 2	Difference	Percent Change
Number of fibers	24	48	24	100%
Cable length (miles)	14	14		
(feet)	73,920	73,920		
Cable base cost per foot	$0.630	$0.630		
Fiber cost per foot per fiber	$0.022	$0.022		
Total fiber cost	$1.158	$1.686	$0.528	46%
Pole line hardware cost per foot	$0.50	$0.50		
Installation cost per foot	$1.00	$1.00		
Number of cable ends	16	16		
Termination equipment per cable end	$2,000.00	$2,200.00	$200.00	10%
Total termination equipment cost	$32,000.00	$35,200.00	$3,200.00	10%
Termination equipment cost per foot	$0.43	$0.48	$0.04	10%
Splicing and termination per cable end per fiber	$75.00	$65.00	-$10.00	-13%
Total splicing and termination cost	$28,800.00	$49,920.00	$21,120.00	73%
Splicing and termination per foot	$0.39	$0.68	$0.29	73%
Total installed cost per foot	$3.48	$4.34	$0.86	25%

Incremental cost per fiber per foot	$0.036