September 19, 1992

Dr. Thomas P. Stanley, Chief Engineer
Federal Communications Commission
2025 M Street, NW
Washington, DC 20554

Re: Southwestern Bell Technology Resources, Inc.
Call Sign KM2XBI
File Number: 3037-EXPL-92
Quarterly Progress Report Number One

Dear Dr. Stanley:

In accordance with the Federal Rules and Regulations Part 5, Section 5.204(b), attached please find the first quarterly progress report for Southwestern Bell Technology Resources, Inc. in connection with our personal/wireless communications testbed in St. Louis, Missouri.

The overall purpose of our testbed is to examine potential wireless access technologies and their operation prior to integration into one of SBC's business units. The first phase of our experiment deals with propagation issues for wireless PBX systems in the indoor environment, and wireless local loop in the outdoor environment, both in the 1.8 GHz band.

Please direct any inquiries to me at 314-529-7567.

Sincerely,

John A. Moore
Director, Wireless Communications

Attachment

FCC Quarterly Progress Report Number One in Connection with Personal/Wireless Communications Testbeds in St. Louis, Missouri

Conducted by Southwestern Bell Technology Resources, Inc.

September 19, 1992

Authorized by FCC Experimental License
Call Sign KM2XBI, File Number 3037-EX-PL-92

1.0 Introduction

Southwestern Bell Corporation (SBC) is active in the area of Personal Communications Services (PCS) and Portable Communications Networks (PCN) research. Our vision of an integrated PCS/PCN environment includes the seamless integration of multiple networks to provide personal services and portability, as shown in Figure 1.1. In the view of SBC, a key element in making this vision a reality is the use of a single handset in multiple environments. If a person has to use one handset at the office, another at home, and still a third in public areas, the vision of person-centered communications may not be achieved.

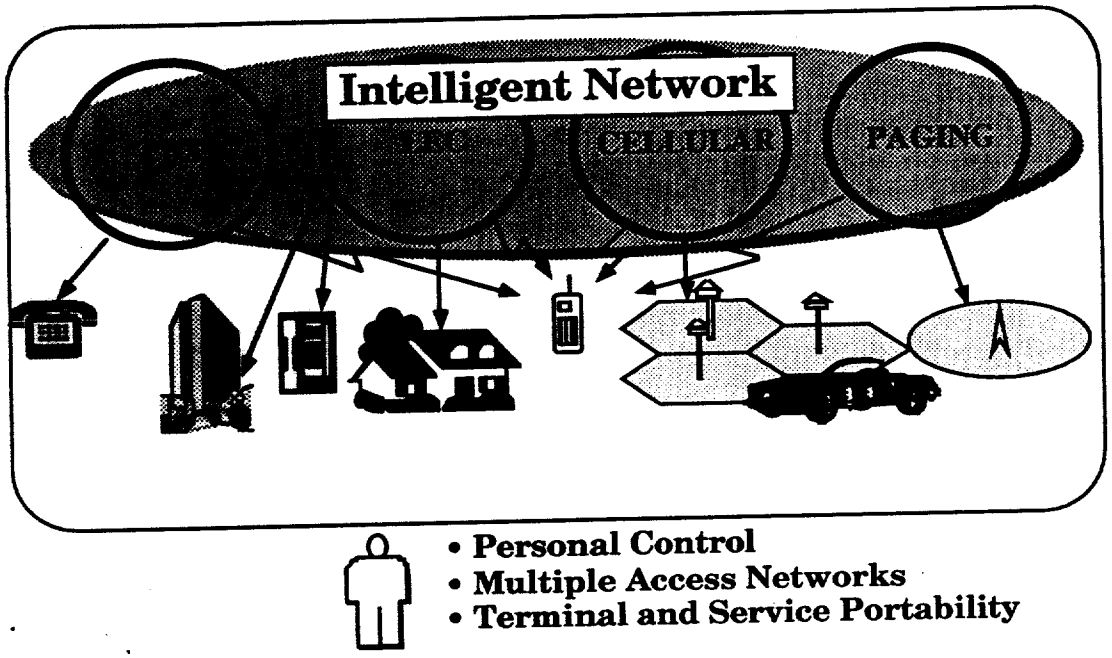

Figure 1.1 SBC's Vision of PCS/PCN

The SBC companies wish to be full service communications providers, and as such are interested in wireless technologies to address a number of important services and applications. SBC subsidiaries currently hold licenses in the cellular band, paging bands, common carrier point-to-point microwave band, and to provide Basic Exchange Telephone Radio Service (BETRS) in rural areas. Technology has advanced to the point that several other services may now be economical. In particular SBC is interested in wireless business systems and wireless local loop (or "drop"). Southwestern Bell Technology Resources, Inc. (SBTR), a wholly owned subsidiary of SBC, is in the process of implementing testbeds, located in the St. Louis area, for these two applications. The overall purpose of these testbeds is to investigate new network architecture solutions for the SBC companies through the use of wireless access techniques and equipment. SBC's approach to wireless drop and wireless business systems will address the PCS/PCN vision as well as consider

these technologies as stand-alone applications, as will be discussed in section 2 of this report.

The experiments planned under this license have been expanded slightly from what was anticipated at the time of the license application. In addition to experimentation at company locations in St. Louis county, testbed activity will also take place within the city of St. Louis and in a residential area of St. Louis county. This activity, however, is included within the scope of the license granted. We wish to make it clear that these testbeds are intended for technical experimentation and testing only, and will involve only SBC employees and equipment. No business or services will be offered to the public.

The target of the wireless drop effort is the economically viable displacement of wired copper drop with radio. The potential for easier and cheaper installation, lower cost of maintenance, and the ease of adding additional phone lines to a residence make this an attractive area for study. We will study, test, and demonstrate the technologies and vendor offerings to determine the technical and economic feasibility of this approach.

Ultimately, it is envisioned that a small radio port (known as a microcell) would be mounted on a telephone pole, light pole, etc. A radio transceiver and interface unit will be placed on the home in order to interface with existing home wiring and CPE (customer premise equipment) for basic telephone service. In addition to technology substitution for the copper drop, the home user could be provided mobility through the use of small, portable phones which communicate directly with the microcell radio port. This would provide enhanced cordless phone functionality inside the home and/or around the yard or neighborhood. Neighborhood coverage could be provided via hand-off from one port to another within a local area. We believe that a common handset across multiple environments will be critical to the success of PCS as envisioned by industry, and it is therefore desirable that a wireless drop system should be implemented with this possibility in mind. This application is illustrated in Figure 1.2.

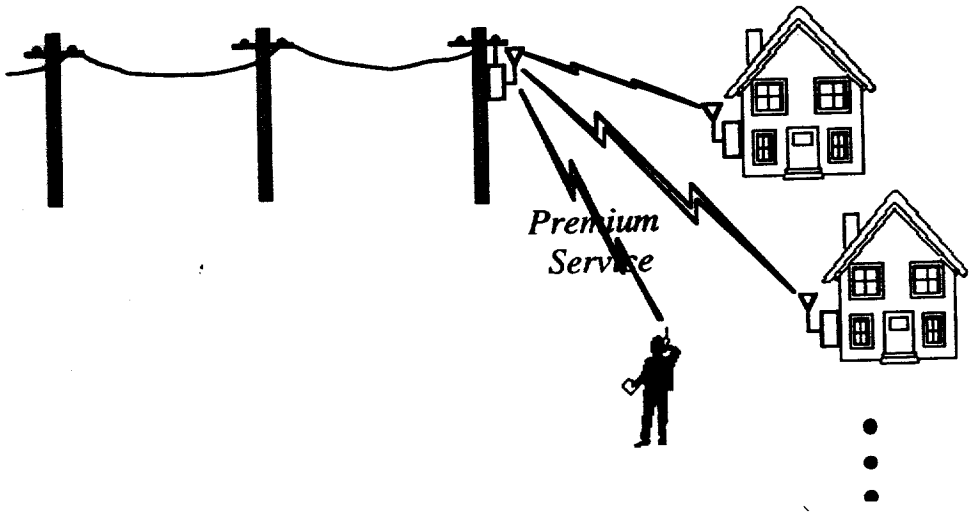

Figure 1.2 - Wireless Drop and User Mobility

The testbed operation will provide the data needed to determine the most suitable technology for implementation of wireless drop, and determine the conditions under which the displacement of copper drop is economically feasible. This testbed will consist of facilities in SBTR's Portable Communications Laboratory, and equipment temporarily deployed in a residential neighborhood where technology alternatives may be exercised and tested in a representative environment. The testbed will involve microcell radio ports, fixed subscriber radio units (FSUs), antennas, and pocket-sized radio terminals from selected vendors. From this testbed activity, generic specifications for desired equipment will be developed and potentially lead to a field trial and eventual full scale deployment where economically justified.

In addition to the wireless drop application, wireless access in a PBX or Centrex environment will be studied through the implementation of a wireless business system testbed. This testbed will provide a framework for the characterization of the in-building office environment, and the study and evaluation of potential indoor wireless business system offerings. The testbed will be implemented in SBC's downtown St. Louis office buildings at One Bell Center (OBC) and next door at 1010 Pine Street. Propagation studies in these buildings will address the issues of multifloor RF penetration, out of building propagation and interference, and in-building coverage and performance.

The aim of a wireless business system is to provide the user with all the features of the existing PBX/Centrex systems but offering the added feature of not needing wired connection to the network. This is a very desirable feature which can increase the work performance and efficiency by allowing the users to receive and initiate calls while away from their offices and in motion about the work environment. Furthermore, wireless business systems are ultimately expected to significantly reduce the cost of in-building wiring as well as the labor associated with installation and rearrangement of terminals.

The wireless business system essentially consists of a number of low power radio ports or base stations (similar to the cellular system in concept) which are connected to the network through one or more radio port control units (RPCUs). The system operates at low power levels which allows more efficient utilization of the spectrum by reuse of frequency in the same building on floors or areas with enough separation, as well as in different buildings. This concept is depicted in Figure 1.3.

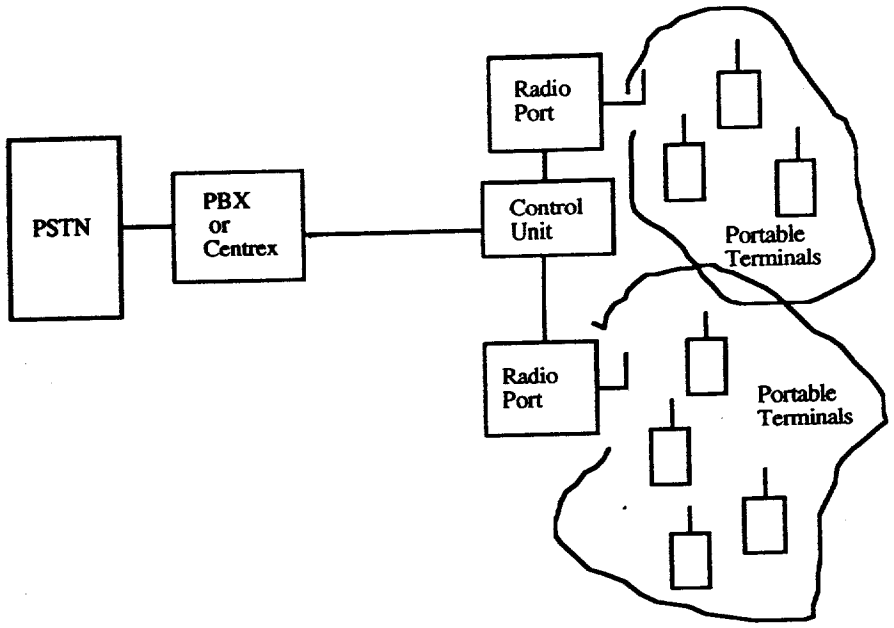

Figure 1.3 - Wireless Business System Concept

A light-weight pocket size terminal will provide seamless coverage throughout the work environment. When outside the coverage area of a radio port, the call will be handed off to another port with proper radio coverage to the user. Ideally, the call would also be handed off to other systems when the user moves outside the coverage area of one system into another. As such, the wireless business system will be part of a universal personal telecommunication network wherein, through a personal number and with the help of the intelligence built into the network, a person could be reached and initiate a call regardless of their location in the network.

2.0 Testbed Descriptions and Approach

2.1 Wireless Drop Testbed

The wireless drop testbed will investigate the technologies and operational requirements involved in replacing the copper drop wire with radio. We anticipate testing multiple technologies as well as varying the parameters of a given technology. Some of the major issues are: voice quality, reliability, economics, transparency to existing CPE, propagation in a suburban microcellular environment, powering, capacity, spectral efficiency, and Operations, Administration, Maintenance and Provisioning (OAM&P).

Our desire to enable the use of wireless portable handsets, in or around the home as well as in other PCS/PCN environments, led us to a decision to test operation in the 1850-1990 MHz band. Our potential to interfere with fixed microwave users will be determined and we will coordinate with any users the experiment might affect. Given the static nature of the testbed, a knowledge of the fixed microwave users in the St. Louis area, and RF environment testing in the selected testbed location, there should be no problem with avoiding any frequency which has the potential to cause interference. We will coordinate closely with licensed spectrum users and ensure that no interference will occur.

The testbed will be implemented in three phases. The first phase will involve RF propagation testing of the selected environment to determine coverage parameters. This will be done with prototype hardware from the selected vendor(s), or with test and measurement gear owned by SBTR. The microcells will then be placed in the testbed environment, and fixed subscriber units (FSUs) will be placed at the homes of the testbed participants. These participants will be SBC employees (more information on the test participants may be found in section 2.3). The first phase will be a fixed application only. The copper drop will remain but will run into an A/B switch whose other input will be the radio I/O. This switch will be under computer control, and the participants will not know whether they are using copper or wireless drop. It is felt that this "blind" test will give more accurate results in questions of perceived quality of voice and low-speed data transmission. The participants will be asked to keep logs for each call indicating the perceived quality, etc.

Phase two of this test will include the addition of limited mobility. More participants will be added to the test, and will be supplied with portable handsets. Neighborhood mobility will be supplied by allowing mobility within a single microcell, and then within a group of microcells as mobility software is included in the controller. The handsets will communicate directly with the outdoor microcells as opposed to indoor base stations. The propagation performance, both indoors and out, and the perceived utility of neighborhood service will be examined. In addition, the capability of the air interface and controller to handle both fixed subscriber units (FSUs) and mobile handsets will be investigated. The FSUs will be on the network side of the network interface unit (NIU), and as such, all the operations and maintenance functionality of the copper drop must be emulated in the wireless drop.

Phase three will entail placing one or more microcell transceivers in a local shopping mall to test the technical parameters of telepoint services for mobile handset users, and to test the ability to supply telephone service to small mobile kiosks, which often take the form of small carts out on the mall floor. Mall operators often do not allow telephone wiring to these kiosks due to their mobility, and the cost in tearing up the floor to supply floor jacks. Ultimately, wireless drop via indoor microcells may make service to these businesses possible in a very convenient and cost effective fashion (businesses will not be involved as part of this experiment). Such a concept is illustrated in Figure 2.1.1.

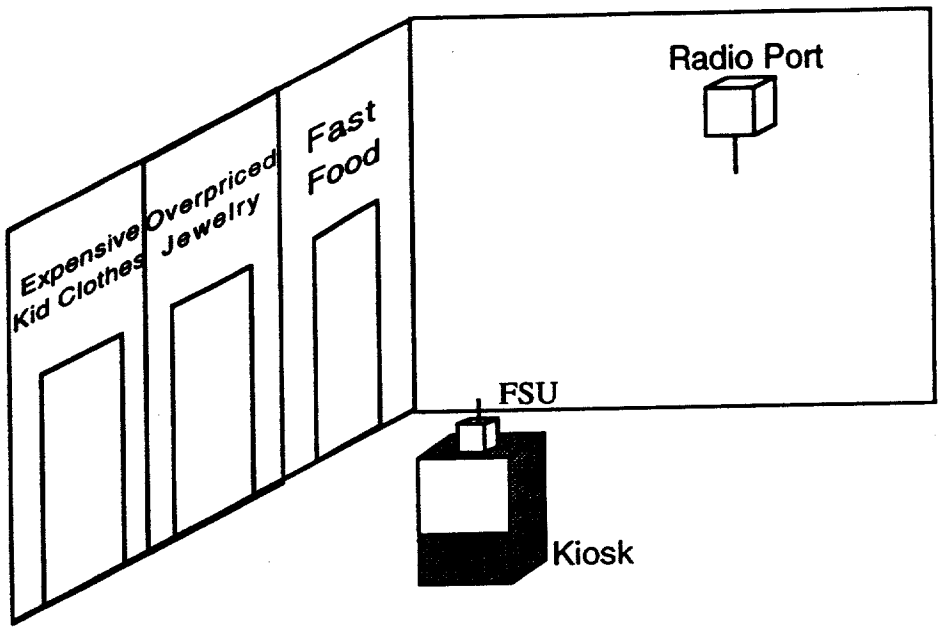

Figure 2.1.1 - Kiosk telephone service via wireless drop technology

Integration of these tests with the wireless business systems testbed will be discussed in section 2.3.

2.2 Wireless Business Systems Testbed

The wireless business systems testbed will enable testing of technology as well as individual vendor offerings and products. It will also provide the means to validate and develop propagation models in the various frequency bands that become allocated for personal communications services. Wireless business systems are likely to operate in the licensed cellular band (on a non-interference basis), the unlicensed 902-928 MHz (FCC Part 15) band, and/or future allocations in the 1850-1990 MHz band (e.g. Part 15+, 1910-1930 MHz).

As part of our stated objectives in the FCC application, a wireless indoor system operating in the 1850 -1990 MHz range will be deployed and tested in the St. Louis area. The first system to be installed is scheduled for delivery in the late August time frame. We have contacted the Engineer in Charge (Mr. James Dailey) at the FCC Regional Office in Kansas City, MO, and prior to installation of our 1850-1990 MHz system we shall file the respective emission sites and levels.

The wireless business system will be experimentally evaluated in terms of radio propagation characteristics, signaling and hand-off efficiencies, voice quality, battery life, and compatibility with Centrex features, as well as equivalency to wired services and user perception. We will also measure the bit error rate (BER) on the transmission path with the receiver in motion. This will provide valuable information on the quality of the system in addition to the subjective voice quality tests.

A set of guidelines will also be developed for installation of wireless indoor systems. The testbed created (wiring and antenna infrastructure) will also allow the evaluation of other wireless systems in the future. These efforts are scheduled for completion by 3Q93.

Our experiments in the 1.8 GHz band will include measurements to assure non-interference with any incumbent microwave users operating in this band. This will be accomplished through measurement of the RF environment both indoors and out. Measurements at all carrier frequencies in this band will be compared against the noise threshold. Both omnidirectional antennas and directional antennas pointed towards microwave license holders will be used.

Where it is possible to operate, based on these measurements, and after filing with the FCC Regional Engineering Office, we will install our experimental systems to perform our tests and analyses.

2.3 Integration of the Testbeds

In order to gain a better understanding of the PCS/PCN environment, and the interaction between the different applications, the wireless drop and wireless business systems testbeds will be integrated through the selection of test participants (selected from SBC employees).

A database of all SBC personnel working in the downtown St. Louis offices was obtained. This database was used as input to a Graphical Information System (GIS) which will plot their home addresses on a map of St. Louis and St. Louis County. From this plot, several candidate locations of the wireless drop testbed were determined (based on density of SBC personnel in these locations). SBC will determine which area represents the best list of participants for the in-building wireless business system testbed. The approach is to have the two groups of test participants overlap as much as possible. In this way, we will more closely represent the future of personal communications where each person has access to these mobile and personal services across multiple environments. This combined group will provide feedback on the quality, reliability, and utility of these services.

3.0 Testbed Progress

3.1 Wireless Drop Testbed

As described in section 2.3 above, a database of SBC employees was obtained and used as input to a Graphical Information System (GIS) software package. This package runs on a SUN computer and allows the display and manipulation of data on-screen in real time. The road database for St. Louis City and County were used along with the employee database. The GIS software plotted the locations of the home addresses of the employees on the screen (see Figure 3.1.1). After examining this plot more closely for the density of employees in various areas, sections labeled A through E were identified as possible testbed locations.

A list of the employees in each of these locations is being examined by SBC to determine the best area in terms of the participants. The initial conclusion is that area A looks to be the most suitable. This area has the highest density of employees, and it is close to both the Manchester Road central office and SBTR. Figure 3.1.2 shows an enlarged map of this area with the employees plotted and potential microcell locations identified (based on a microcell range of 1000 feet). This area is composed of one- and two-story single family houses. The houses are primarily frame construction with brick facades, and typically have basements. The area is quite hilly and there is dense tree cover with heights up to about 60 feet. The propagation environment will be investigated for cell range and shape. It is our desire to also determine the effects of foliage on 2 GHz propagation by measuring signal strength in the summer and winter in the same locations. Another interesting aspect of this testbed location is that some of the neighborhoods in the area have no above ground power or telephone facilities. The street lights are made to look like old gas lights and are only 10-12 feet high. These light poles are not adequate for the mounting of microcell radio ports. We will have to address the neighborhood rules and determine how to deploy microcells in such an area (both in mounting and powering). Since this is fairly typical of newer subdivisions, this location will provide a good test case.

A database of licensed operators in the following bands was obtained from Comsearch:

- 902-928 MHz Auto. Vehicle Monitoring,
- 1850-1990 MHz Private microwave,
- 2110-2130 MHz Common Carrier Microwave,
- 2130-2150 MHz Private Microwave,
- 2160-2180 MHz Common Carrier Microwave,
- 2180-2200 MHz Private Microwave, and
- 2450-2483.5 MHz Mobile TV Microwave.

This data was also input to the GIS software and overlaid on the street and population data. The result for testbed location A in the 1850 -1990 MHz band is shown in Figure 3.1.3.

Figure 3.1.1 - Distribution of SBC employees in the St. Louis area

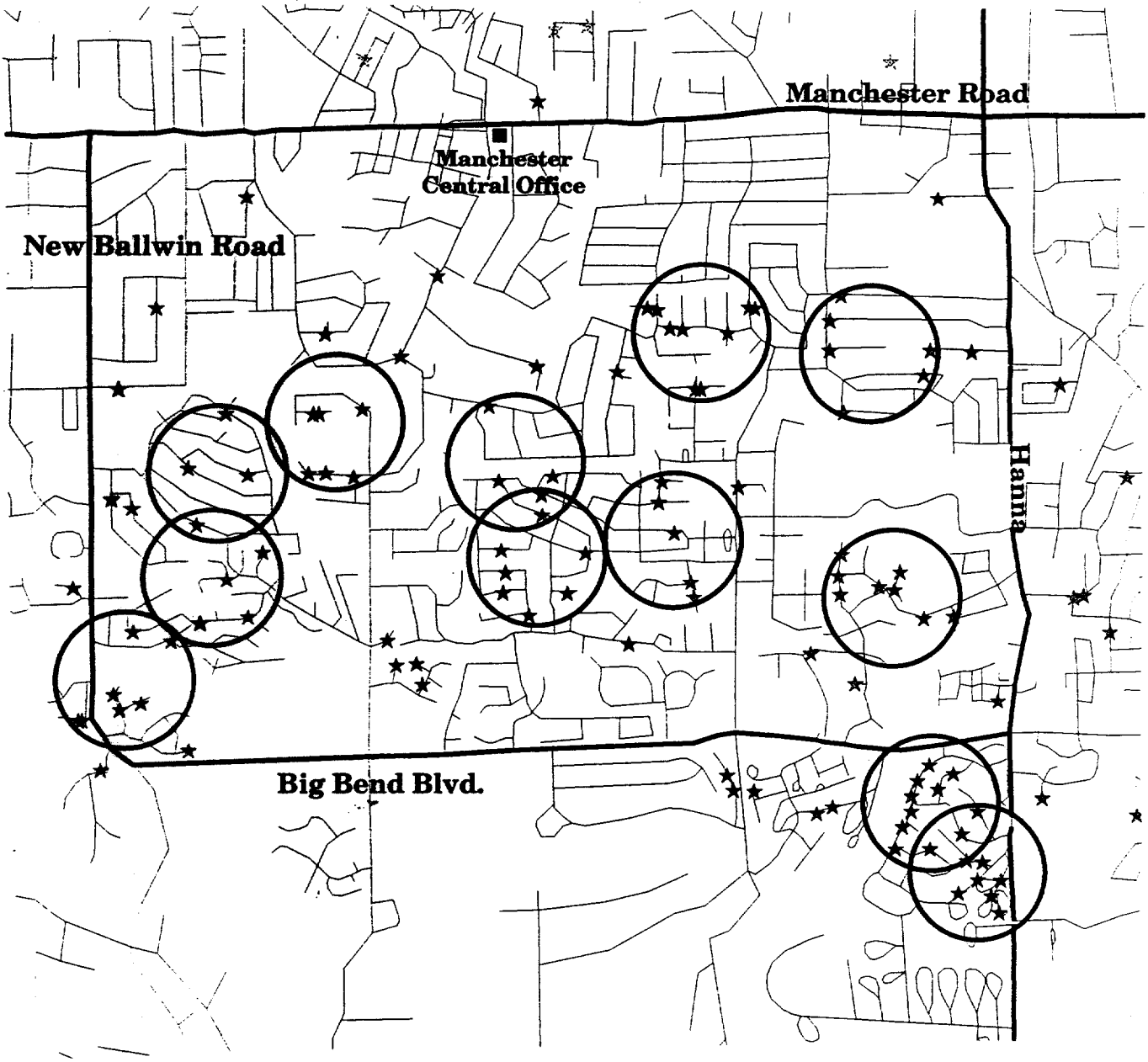

Figure 3.1.2 - Candidate West St. Louis County testbed location

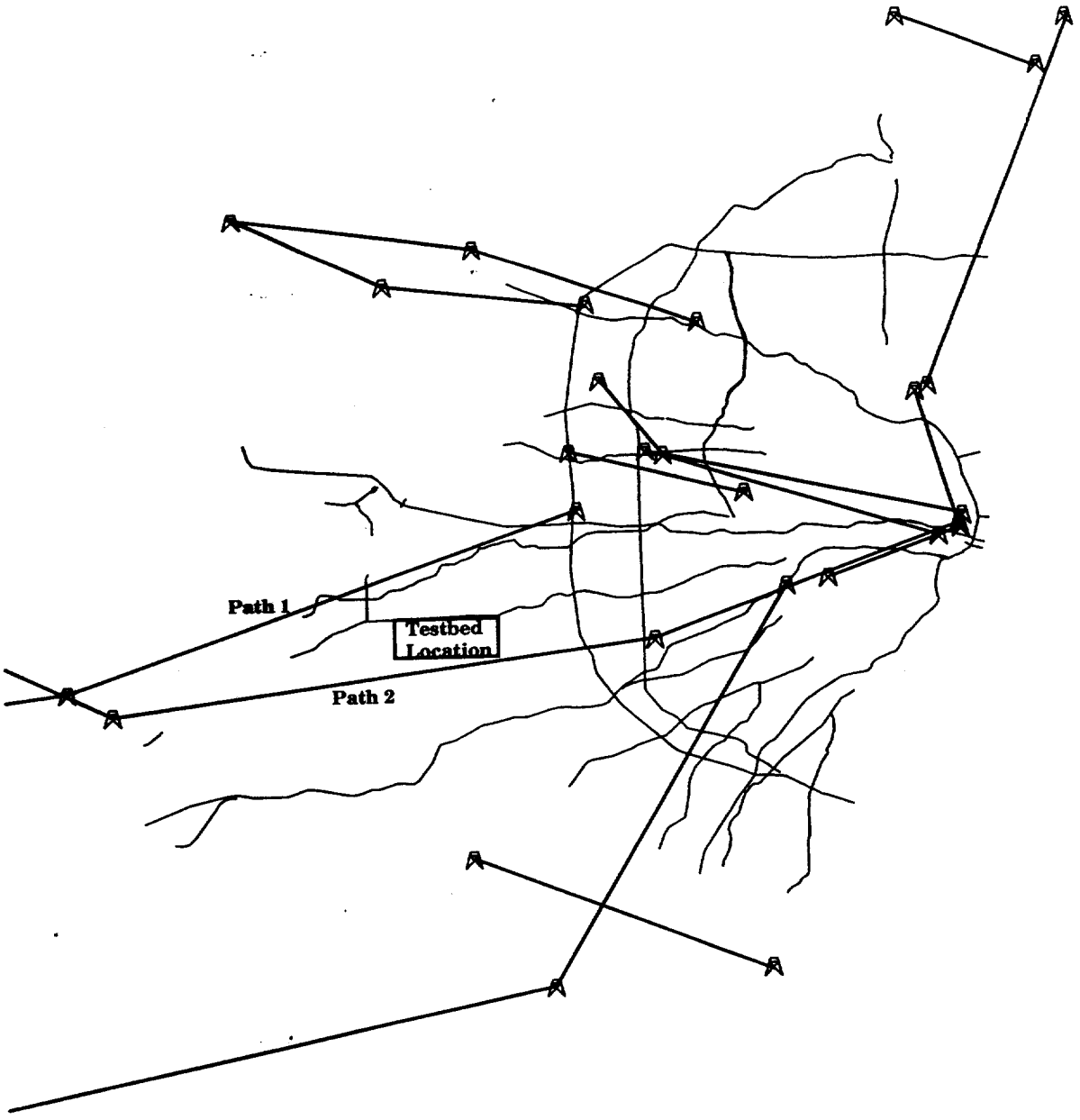

Figure 3.1.3 - Microwave path overlay for location A in the 1850-1990 MHz band

This plot indicates that there are two microwave links near the testbed area, these are designated Path 1 and Path 2. Path 1 is operated by St. John's Mercy Medical Center, a local hospital with a link to a satellite operation in Labadie, Mo. The total distance is 19

miles, using digital modulation, and frequencies of 1890 MHz and 1970 MHz, vertically polarized. Path 2 is operated by Missouri Pacific Railroad Company. It has one site in Kirkwood, Mo. (a suburb of St. Louis) and the other site in Pacific, Mo. The total link distance is 19.3 miles, using analog modulation, and frequencies of 1965 MHz and 1885 MHz, horizontally polarized. It would appear that the distances from the testbed area to the microwave receiver sites is great enough that no interference should occur at our low transmit powers. However, RF measurements of the frequency spectrum around the testbed area should indicate whether or not interference is possible using the EIA/TIA Telecommunications Service Bulletin TSB10-E[1] criteria. If it appears that interference is possible, we will avoid those frequencies in our transmissions. We will coordinate closely with these operators and with the FCC field office to ensure that no interference occurs. We will also notify them before broadcasting with any of our RF equipment as required by FCC rules.

In March of 1992, we sent an RFI (request for information) to the radio industry asking for information on their radio systems and how they would address the wireless drop application. From the responses we received in May 1992, we have identified two suppliers with the potential to meet our testbed needs. We are currently in detailed discussions and negotiations with these suppliers and expect to select the initial equipment supplier within the next month. Our intention is to test multiple technologies and supplier equipment in this testbed. This may be done in parallel or serially depending on available resources. This approach will allow us to better determine which technologies provide the best performance and economy in this application.

3.2 Wireless Business Systems Testbed

We have been engaged in the process of vendor negotiations to acquire a suitable wireless business system for the past 15 months. Presently we have deployed a wireless business system operating in the 902-928 MHz (Part 15) band in our west St. Louis county facilities (SBTR building). To further test the propagation characteristics as well as user response, we also have plans to expand this system by installing more base stations and controllers in our building at One Bell Center (SBC headquarters), with wireless phones made available to selected technical and marketing staffs as well as executives. We have also deployed a wireless business system operating at 800 MHz under developmental authority.

We have planned to install a wireless business system in our downtown St. Louis facilities, covering a total of 10 floors (each about 10,000 square feet), with about 100 hand-held units made available to SBC employees in marketing, engineering, and administration. Each floor will have 4 to 6 radio ports (base stations), all with call hand-off capability.

By the end of August we are scheduled to receive the Motorola CT2 CAI (Common Air Interface) system operating in the 1850-1990 MHz band. This is a FDMA/TDD system with forty 100 KHz channels transmitting 10 mW ERP, using 32 kbps ADPCM voice coding. This system will operate in conjunction with a PBX or Centrex system providing wireless access, although the radio ports form isolated service cells and are not capable of call hand-offs. The propagation characteristics and other features of interest, however, can be tested with this system. This system will also be tested briefly in the wireless drop environment to determine coverage and performance. This system may also be placed in the indoor telepoint environment for testing.

4.0 Future Plans

The next step in the wireless drop testbed work is to begin propagation studies of the selected testbed site. The hilly nature of the terrain, and the foliage conditions, may lead to some interesting coverage patterns for antennas at low mounting heights (15-18 ft). Signal strength measurements will be taken outdoors around the homes, and inside some of the homes to determine where indoor coverage would and would not be available based on terrain, building materials, and distance from the microcell transceiver. If it is desired to cover the insides of homes to allow portable handsets to be used like cordless phones, this will impact the microcell spacing and thus the economics of the infrastructure. On the other hand, capacity considerations may dictate a spacing approach which results in adequate indoor coverage anyway. These issues will be addressed to determine the technical capabilities, and the economic breakpoints, for various service scenarios.

Once equipment selection is completed and the equipment is received by SBTR, laboratory tests will be performed both for equipment acceptance and for equipment characterization. The equipment will then be placed in the outdoor testbed and interfaced to the Public Switched Telephone Network (PSTN). The FSUs will be interfaced to the test participants' home telephone wiring via standard RJ-11 interface as shown in Figure 4.1.1. It will provide all required functionality, signaling, and power required to operate with current CPE. In addition, the FSU will have functionality to emulate the test and maintenance capabilities currently found in wired drops plus those needed to specifically test radio links.

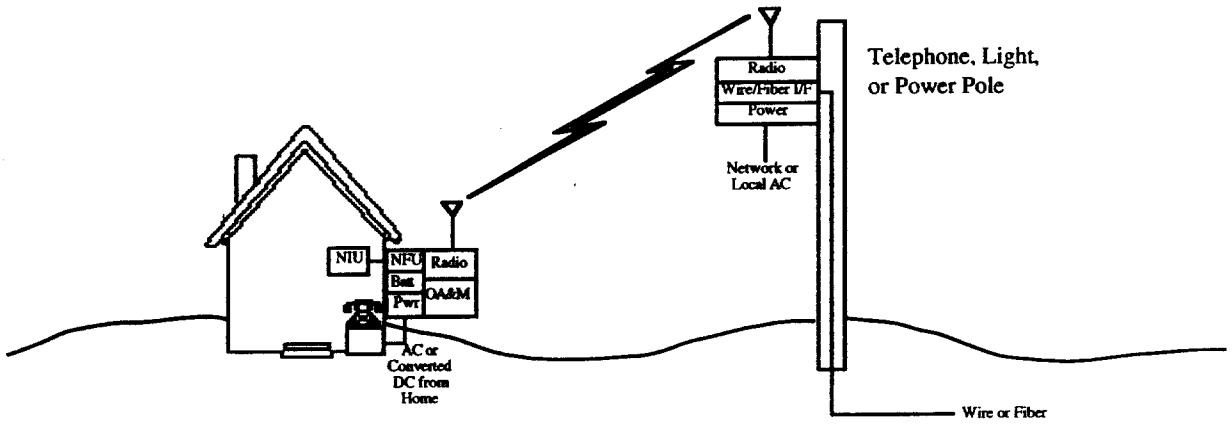

Figure 4.1.1 - Interface of the wireless drop equipment to home wiring and CPE

We expect to begin field testing of the deployed wireless drop equipment early in the second quarter of 1993. The testbed will later be expanded to involve approximately 50

test homes (owned by SBC employees). As portable handsets and mobility management hardware and software become available, we will investigate the integration of mobility in this application. In addition to voice quality, such mobility issues as alerting, hand-off, coverage, and use in other environments will be examined. The technical issues we intend to address include:

- Perceived quality (voice)
- Blocking
- Reliability
- Spectral efficiency
- Capacity
- Coverage/range
- OA&M features and support
- Impact on current OSS (Operation Support Systems)
- Frequency/code reuse and interference characteristics
- Ability to support custom calling features
- Support of extension phones
- User transparency
- Compatibility with voice-band data products to a minimum of 2400 baud (computer modems, fax, etc.)
- Powering
- Cost of installation, provisioning, and maintenance/servicing
- Generation of required tones (busy, ringing, off-hook, etc.)
- Diversity protection (micro-diversity and macro-diversity)
- Frequency/code planning requirements
- Frequency/code assignment approach and performance
- Talk time and reserve time of portable handsets
- Coverage into the home to enable use of the portable as a cordless phone
- Handset registration
- Hand-off (if neighborhood cordless is implemented)
- Roaming for call delivery (if neighborhood cordless is implemented)

In addition to placing equipment in the selected neighborhood, one or more microcells will be placed in a local shopping mall. Two applications will be tested with these microcells: telepoint services, and telephone service to small, movable kiosks. The SBC users involved in the wireless drop and wireless Centrex testbeds will also test the telepoint application. The shopping mall is near the downtown SBC offices and is frequented by these employees for lunch and shopping.

As previously mentioned, within many modern shopping malls, small businesses operate out of small, movable carts or temporary retail stands out on the floor of the hallways. Due to the cost and disruption of tearing up flooring to add telephone wires, not to mention the fact that the kiosks are movable or temporary, these businesses cannot obtain standard telephone service. Their only possibility is to use cellular service if they have sufficient signal strength within the structure and they can afford the cost of this service as a primary telephone line. The use of this wireless drop technology has the potential for supplying these kiosks with telephone service, with no disruption to the mall or other retailers, as well as simultaneously supplying the telepoint needs of the mall patrons. SBTR will test the technical issues involved in supplying such a service.

The eventual goal of this testbed activity is to derive the desired requirements for a wireless drop system as an economical technology displacement in new construction and rehabilitation of old plant, and to simultaneously provide the air interface required to supply PCN coverage in residential areas. In these residential areas, the mobile users would most often be the area homeowners. Thus, the total traffic presented will not likely be much more than if the usage was strictly fixed. This being the case, neighborhood radio ports may eventually provide for both fixed wireless drop and mobile use (PCN) in the residential neighborhood. This would lead to the efficient use of valuable RF spectrum for multiple services in the same area, and the use of a universal personal handset.

5.0 Expected Progress for the Second Quarterly Report

By the submission of the next progress report, we expect to have accomplished the following:

- the participants for the testbeds will have been identified,
- we will have selected one or more initial vendors,
- we will have made initial propagation studies of the testbed areas,
- we will have established a working relationship with any existing spectrum licensees which might be concerned with the effects of our testing, and
- we will have begun testing of the Motorola CT2 CAI equipment in the different environments.

References

1. "Interference Criteria for Microwave Systems in the Private Radio Services," TSB10-E, Electronic Industries Association, Engineering Department, November 1990.