of optical repeaters at 41 mile intervals for interoffice service.[12] They assert that a design engineer would place such repeaters at central offices located along the interoffice route. This is a peculiar and untenable assumption presumably made to avoid the true costs of providing shelters or housings for the equipment.

The assertion that "there is normally an appropriate wire center location along the route to provide for this equipment installation" is spurious and misleading. They must still provide for land costs, floor space, equipment racks, building entrance, power, battery backup and similar site costs even if they placed the equipment in this suspicously convenient intervening wire center building.

The Hatfield Model assumes that an increase in cable length of 20 percent will compensate adequately for hard rock conditions during construction. The model's assumption, as explicated by the sponsors, is that: "The typical response to hard rock conditions is not to blast away the rock for telecommunications cable, but simply to route cable around those conditions where rock is at a depth of one foot or less."[13]

This is unrealistic and simplistic. Without reviewing the merits of "blasting," which may indeed be required in certain restricted mountainous rights-of-way, it is quite likely that construction will require preparatory work, such as pre-ripping or other geologic condition-specific placement methods, such as rock sawing or rock wheeling. The physical environment may well dictate use of techniques, which often are reasonable, sensible and rational engineering practice even if not mandatory Engineers cannot in every case "simply ... route cable around those conditions," particularly in built-up areas.

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[12] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, miscellaneous input tables.

[13] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, page 23.

The Hatfield Model considers differences in population density by assigning a fixed number of distribution lines to areas of given population densities. The is an inappropriate methodology given the uneven pattern of human settlement, particularly in low and medium density areas. It would be preferable to use the average lot size in each CBG, combined with the number of households, to spread the distribution legs.

The Hatfield Model only permits network design with one SAI per CBG. Existing allocation areas, which in urban areas would be comparable in size to a CBG, often contain two or more SAIs, at about 3,000 pairs to 3,600 pairs per SAI. This limitation will make the design unreasonable and inadequate.

The Hatfield Model does not handle situations in which multiple wire centers serve a given CBG.

The Hatfield Model assumes the application of traditional feeder-distribution (dendritic) design principles. It does not appear possible to incorporate contemporary SONET fiber ring topologies in the feeder network, although the sponsors of the model assert that interoffice trunks run on SONET.

In their supplementary filing, the sponsors of the Hatfield Model stated that: "Extensive use of fiber-fed Integrated Digital Loop Carrier (DLC) in the feeder, with its attendant 0 dB loss at the Remote Terminal point, provides for a robust feeder facility." [14] How do they achieve 0 dB loss? This accomplishment would constitute a significant advance over current technology unless the designers are assuming signal regeneration between the central office and the remote terminal. Because no costs are specified for such regeneration, we believe the zero loss argument is spurious.

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[14] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, page 19.

After exceeding the capacity of a cable, the Hatfield Model automatically selects the next larger cable size, rather than selecting a second cable. This is not sound engineering and certainly is not least cost engineering. This will be most significant at the 2,400 breakpoint, where there is also a default transition in wire gauge from 24 gauge to 26 gauge. This could significantly impact the transmission network.

### *Drops*

The Hatfield Model assumes a standard cost for terminals and drops. In reality, these costs vary greatly between zones of differing population density. Within more densely populated areas, where subscribers concentrate closer together, the design engineer can spread installation costs over a larger number of subscribers, particularly when pre-wiring sub-divisions.

In addition, equipment costs vary with population density. For example, the installed cost of a buried terminal is approximately $450 and the maximum allowable distance for a buried service drop is 900 feet from the terminal to a Network Interface Device ("NID"). In rural areas, families may reside more than 900 feet from a terminal, thus requiring one terminal per household or an average cost of $450 per household. In urban or suburban areas, 5 or 6 households may reside within a terminal's range, resulting in an average terminal cost of $75 per household.

The Hatfield Model uses fixed, idiosyncratic costs of questionable veracity (for example, the costs reported in the New Hampshire cost study for drops and Network Interface Devices). The price specified for a Network Interface Device -- $30 -- is too low by at least 20 percent. The Hatfield Model specified a cost per line for a terminal and splice of $35. This cost also is too low by at least 20 percent. Finally, the Hatfield Model specified a price for a house drop: of $40, which also is too low by at least 20 percent

Finally, the Hatfield Model does not distinguish between drop types or allow for differences in drop length.

### *Interoffice/Inter-Exchange*

The Hatfield Model assumes all interoffice traffic travels over 24 strand fiber (equipped with OC-12 electronics to provide 12 DS3s). This assumption, which may be a function of the model's emphasis on large carriers, results in an over design of the capacity for low density area routes. Moreover, it skews their associated switch costs. For example, the model understates FOT costs for interoffice facilities significantly.

### *Land*

We suspect that the Hatfield Model misstates land costs. The costs for land for the smaller sites appear to reflect the cost for rooms, which assumes existing facilities. This may or may not be reasonable in the rural areas.

### *Loop*

Besides many unrealistic input values, the Hatfield Model includes loop design errors and engineering assumption cost mismatches that result in meaningless output cost levels. The model produces designs that either do not reach many of the subscriber locations or reach them with a pair of wires that cannot produce a dial tone. Moreover, the designs the model produces do not comply with a least one sponsor's specifications for resisteance design.[15]

The Hatfield Model incorporates a module, termed the Convergence Module.. This module incorporates design principles that reflect an increase in the number of distribu-

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[15] *Outside Plant Engineering Handbook*, January, 1990, AT&T Document Development Organization, Winston-Salem, North Carolina, especially "Section 5 - Transmission" pages 5-1 to 5-35.

tion cables within the CBG in the highest density groups and a reduction in the lowest density group. The density group of 0-5 households per square mile has only two distribution cables that are a multiple of 0.625 of the length of the side of the assumed (square) CBG area in length. These cables cannot possibly reach the subscriber locations unless the totally arbitrary assumption that all households reside very close to the CBG centroid should prove to be the case. In this respect, the Hatfield Model perpetuates a methodology that many engineers criticized as a serious flaw of the original BCM.

The Hatfield Model does not include adjustments to the distribution area to prohibit the placement of cable in unoccupied areas.

The Hatfield Model does not include a complete engineering design of the plant facilities within each CBG. The model does not incorporate the extension of feeder to an appropriate number of SAIs. In high population density areas, the model does not provide for a capacity driven, lower cost fiber alternative. The model also does not recognize that there is a high likelihood of conduit congestion in such high density areas. The model should invoke the economies of replacing copper with fiber instead of placing relief conduit.

There are a number of serious flaws that make at least the loop portion of the model unusable. The design process will produce many loops that physically will not work. Incorrect loop engineering assumptions preclude many of the subscribers from being able to have a basic 2 wire circuit with dial tone. Costing has either missing units or greatly understated unit costs. The Hatfield Model uses one set of cable costs yet is attempting to put large size cables in conduit while at the same time designing untreated copper loops that exceed 18,000 feet or even 37,236 feet in Florida. The 4,200 pair cable that the Hatfield Model places must be 26 gauge to fit in conduit. The length of loops used in the Hatfield Model design require 22 and 19 gauge hence an entirely different set of cable costs but there is no provision for copper pairs of those gauges in the design.

The 18,000 foot (and longer) loops require load coils which in turn preclude such services as higher speed modem links, ISDN, and the use of carrier frequencies to carry T-1/DS-1 type services to the customer. Without all the long loop design cost adjustments such as gauge changes, loading, and loop amplifiers, the Hatfield Model has significantly under designed the loop.[16]

Of serious concern is one change from the original BCM that Hatfield Model incorporates in calculating the transition point from fiber cable to copper cable. The Hatfield Model measures the length of feeder cable and compares it to a 9,000 foot test. The model uses copper cable whenever the length of the feeder route is less than 9,000 feet.

However, unlike the original BCM, the Hatfield Model ignores the length of copper cable in the distribution. The result is that the Hatfield Model continues to place copper for loop distances that exceed the working limits of an untreated copper loop. Loop design requires that different gauge cables or other alternatives be used but the Hatfield Model does not permit changes in gauge for this purpose.

This flaw yields results in untreated copper loop lengths behind the fiber terminal that are much longer than the 18,000 feet limit (in one case 99,868 feet long). Such loops would not function unless the engineer uses 19 gauge copper, load coils, and line amplifiers. There are many more in the data with distribution lengths well beyond an acceptable 1,500 ohm resistance design maximum.

The total length of distribution cable placed by the model is insufficient to reach all subscribers. The Hatfield Model assumes a square distribution area in its calculations. It proposes serving this area with a number of cables that are 5/8 of the length of the side

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[16] *Outside Plant Engineering Handbook*, January, 1990, AT&T Document Development Organization, Winston-Salem, North Carolina, page 5-13 and following.

of the square (3/4 of the length if rock is present within one foot of the surface or if soil is difficult).

In the model calculations, this results in very large areas being served by 2 cables that only go 5/8 of a side. Test calculations have yielded untenable designs in several cases. For example, it is not possible for 2 cables that are 5/8 of a side to serve, in one case, 915 square miles with cables just under 100,000 feet in length. In another example calculation, the design specified serving 824 square miles with cables approximately 94,700 feet in length. In this case, substantial amounts of cable, structure, and placement costs are omitted from the calculated costs of placement.

### *Manhole*

It appears that the method of designing underground systems will result in one less manhole than required for every system.

The Hatfield Model makes no provision for manholes in the distribution system. Manhole spacings in the distribution system should default to a shorter distance than manhole spacings in the feeder network because the distribution manholes serve smaller areas.

In more densely populated areas, manhole costs in the feeder network should be almost twice the $3,000 specified by the Hatfield Model. The $3,000 corresponds to purchase and placement of a small Type A handhole (4 feet X 6 feet X 7 feet) which is only sufficient and appropriate for feeder networks in less densely populated areas and for some distribution areas. The full-sized manhole required by the model's proposed networks would caost approximately $3,000 for materials and approximately $2,000 (or more) for placement.

### *Plausibility*

The model apparently incorporates no provision for growth, presumably because of the "green field" approach dictated by the forward-looking cost assumption. However, sound engineering principles and least total cost economic planning principles dictate the assumption of some growth and the design of a distribution system that will accommodate ultimate demand. This is particularly compelling in view of the expected growth in demand for services that the Joint Board currently defines as "unsupported".

The Hatfield Model assumes that the ELEC or ILEC will build this network instantaneously. This, of course, is an unreasonable assumption. This is more than a philosophical problem. The assumption precludes satisfying the model's expectations related to joint construction and structure sharing, certainly for buried placement and probably for many underground placements.

The Hatfield Model assumes that the ELEC or the ILEC will build the local network to satisfy a perfectly known demand. Consequently, the model does not appear to include any break down of costs to reflect variable construction quantities. This makes any attempt to compare the specified unit prices with professional experience very difficult.

### *Poles*

It appears that the method of specifying span lengths and distances, hence, the number of poles, will result in one less pole than required for every pole line. The Hatfield Model formula for calculating the numbers of required poles divides the total aerial plant distance by a span length of 150 feet and rounds up to the nearest whole number. For example, if a pole line includes just one aerial span that is 125 feet, the Hatfield Model will calculate the need for just one pole. If the pole line is 290 feet, the Hatfield Model will calculate the need for two poles, instead of the three poles that the pole line actual requires.

This will be a particular problem in areas where the average length of the spans differs from the assumed 150 feet. In those areas, it is insufficient simply to add one pole to the calculated requirement. The model's designers must change the algorithm.

### *Serving Area Interface*

The Hatfield Model uses a single SAI per CBG regardless of the number of lines served by the SAI. This results in a SAI serving as many as 35,000 lines. Again, this is not possible. Proper design requires that the 35,000 lines be assigned across multiple SAIs. The Hatfield Model has not done that. Costs for additional SAIs are missing from the Hatfield Model results.

### *Switch*

The Hatfield Model does not appear to support proper host/remote switching designs. We base this statement in large on the cost data used within the model. Although the model suggests the use of remote terminals, the only cost data provided appear to be derived from I central office "per-line" costs. We recommend an evaluation of the data and clarification of this issue.

The switch room sizes seem unrealistic. The values used appear to equate to 2,000 square feet per 10,000 lines for a 50,000 line switch, which is larger than normal and not compatible with the 5,000 lines value. Also, it is unclear if all associated costs for ancillary equipment are included in the costs for smaller line count switches.

The 25,000 line and 50,000 line switch sites are major site builds. The costs used do not reflect the substantially higher construction costs associated with such a build. The Hatfield Model appears to reflect the costs associated with small room or small site switches and to exclude costs for power and similar ancillary equipment.

### *Terrain*

The Hatfield Model makes no provision for the impact of groundwater on the cost of cable placement as a simple cost multiplier.

While the model recognizes the impact of hard rock, it only adjusts the input value if the bedrock is within one foot of the surface. Moreover, the model assigns no cost multiplier for any amount of soft rock, at any depth. These assumptions totally understate the real cost of placing facilities.

The Hatfield Model claims it is easier to go around difficult terrain than to go through it. They simply add 20 percent more cable. This is an unreasonable assertion. Utilities must follow right of ways or utilities easements that typically follow property lines, highways, or similar features and do not meander haphazardly wherever the ground looks soft and inexpensive.

## Materials

### *Cables*

Copper cable costs are not well documented or easily interpreted in the Hatfield Model. It does appear clear, however, that the costs used in the Hatfield Model do not include labor costs. The costs do not reflect the difference in price to place and splice cable in the distribution system versus the feeder system. However, if the costs are just for the materials and taxes, the cost appears to be extremely high.

The cost of fiber cable should be different depending on the method of placement (underground, aerial, or buried). Factors such as the composition of the cable, external sheath type, and the type of internal strength member contribute to these differences. In addition, current engineering practice may dictate use of extruded duct for buried cable (for example, Tamaqua duct). Self-supporting aerial cable would be more expensive

than normal cable. Also, it is not clear if the costs for aerial cable include the cost of Kevlar (or similar) strand, to maintain a fully dielectric system. The system should recognize the fundamental differences in fiber cable costs in its default values and be easily modifiable.

### *Poles*

The prices for poles quoted throughout the Hatfield Model are appropriate only for 30 foot, class 6 wood poles. The model assumes a pole cost of $450. This cost is too low, and the pole too small, to sustain another assumption of the model: that there are 2 other utilities attached to the pole. The telephone company would need to place a 40 foot, class 4 pole, at a cost of $693, to accommodate secondary power. The telephone company would need to place a 45 foot, class 4 pole, at a cost of $765, to accommodate primary and secondary power. If this is true, the level of structure sharing specified in the Hatfield Model would be impossible.

## User Inputs

### *Cable*

In their supplementary filing, the sponsors of the Hatfield Model note that conduit installation costs for copper feeder cable and fiber feeder cable are the same for all population densities except in areas with a population density greater than 2,550. In that instance, conduit installation costs decrease by $5 per foot. There is no reason for this change.

The costs of installing buried cable are understated substantially, especially for the density zone of from 1 to 5 households. The already unrealistically low cost per foot for trenching becomes ludicrous when that cost is divided according to the structure sharing proposed in the model.

The cable costs that the Hatfield Model specifies apply to the least cost cables. The loops that the model designs will require heavier gauge cables. In their supplementary filing, the sponsors of the Hatfield Model note that the model assumes that cables with 2,400 or fewer pairs contain 24 gauge copper wires. They also note that the model assumes that cables with more than 2,400 pairs contain 26 gauge copper because "24 gauge copper cables are not manufactured in sizes larger than 2,400 pairs." This will skew cable costs and affect transmission characteristics significantly.

The Hatfield Model tables display variable costs for fiber cable inclusive of engineering, delivery, and installation, as well as the actual cost of the cable. The table for Fiber Feeder Buried installation costs includes an additional cost per foot for burial. This will increase the cost for fiber feeder, as there is no mechanism to reduce the proportionate amount of cable costs for installation, which already is built into the fiber feeder costs.

### *Conduit*

The Hatfield Model assumes a very low constant price per foot for conduit. This single

cost makes no provision for bends, sweeps, ells, unions, caps, solvents, or PVC cement. The model appears to make no provision for unusual situations in conduit systems, such as areas requiring galvanized iron pipe ("GIP") or black iron pipe ("BIP") laterals, risers, or river crossings.

There are inconsistent references in the Hatfield Model, as shown in the cost tables for conduit that suggest a four way system with pricing of $4 per conduit, or an average of $1 per foot. The sponsors should clarify this point in the model.

### *Construction Costs*

Construction costs per square foot for 50,000 line switches should not be twice the construction costs per square foot for 999 line switches. The costs shown for smaller line facilities appear to refer to the costs of room build-outs or allocation costs rather than new building costs. New building costs would maintain a more consistent cost per square foot on average.

### *Discounts*

The Hatfield Model does not accept user defined discount factors. This will be a disadvantage when using the model for smaller companies and in non-Bell serving areas. This is because smaller ILECs and ELECs will be operating with smaller subscriber bases and therefore will enjoy smaller discount levels than those afforded to Bell Operating Companies in large urban areas. The Hatfield Model ignores the higher costs that ILECs will face as a result of losing discounts associated with economies of scale and scope (versus current pricing). Moreover, the Hatfield Model ignores the higher costs that ELECs will face as a result of losing discounts associated with economies of scale and scope (versus current pricing).

### *Labor Rates*

There is no documentation of the labor rates. The cable costs appear to include labor dollars, but we cannot confirm this with certainty. Without isolating the labor costs, it is impossible to confirm their accuracy. Moreover, it will be impossible to confirm their applicability by region to incorporate variations in labor rates.

An EF&I labor rate of $55 per hour is too low by half if company personnel are doing the work. The loaded labor rate for company personnel would be closer to $130 per hour. In conjunction with this item, the new model uses unit rate costs for patch panels and for pigtails and then inserts this line item for EF&I for exactly the same associated costs. Does the model input both or is the EF&I shown for reference only?

### *Land*

The model implies that the per foot cost of land increases with the amount of land purchased. The land area for COs is usually the same. Arguably, the larger the CO, the closer the walls are to the fence (because of standardization in parcel sizes and purchasing practices). This is evidence of the interoffice or inter-exchange carrier bias of the model. The designers of the model should give greater consideration to actual land costs to establish a more meaningful set of default values.

### *Line Cards*

The Hatfield Model contains an incorrect downward adjustment of the line card prices. The model uses modified versions of values published in the *U.S. Central Office Equipment Market: 1995 Edition*. Northern Business Information, the division of McGraw-Hill responsible for producing this publication, has provided independent confirmation of the impropriety of these modifications.[17]

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[17] Correspondence from Mr. William L. Hahn, Inquiry Analyst, Northern Business Information to Ms.

### *Manholes*

Assuming the purchase of fiber cable in minimum 2 kilometer lengths, and assuming the manhole spacing of 1,000 feet shown in the model, it appears that the model makes no provision for splicing and racking. Manhole spacings of 900 feet (center to center) would yield better results for this reason.

### *Pay Stations*

We have no comment on the price of $1,200 used in the model. However, this is not a supported service and we question why the model includes this information.

### *Regenerator*

The cost of $15,000 is unreasonably low. Given that MCI's historical price was $150,000 for a typical area, we suggest that a typographical error may be present.

### *Resurfacing*

The Hatfield Model specifies a cost for resurfacing of $10 per square foot of unspecified lift This cost appears to be too high by a factor of at least 3, depending on the lift or thickness of the resurfacing.

### *Scale*

The Hatfield Model restricts input data to CBGs served by Bell Operating Companies.

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Robin Sanders, Bell Atlantic (undated, facsimile transmitted September 13, 1996). Mr. Hahn's comments were explicated in a memorandum from K. J. Kelly (Senior Analyst, Northern Business Information) and Lance Lindstrom (Managing Director, Northern Business Information) that was transmitted as an attachment to this letter on September 13, 1996.

Christensen Associates' analysis demonstrates that the model is thus "eliminating many of the highest-cost Census Block Groups (CBGs) from its calculations. Using the Bell-only costs to portray costs for the rest of the state results in a significant understatement of non-Bell costs."

### *Splicing*

The Hatfield Model specified 20,000 feet spacing between fiber splices, which is quite unrealistic. To minimize splice costs, the best possible splice intervals would be approximately 15.9 kilometers (approximately 9,700 feet). This is because, given current normal technology, the maximum length of (for example) 24 fiber cable that will fit on a standard reel is 16 kilometers. Typically, design engineers would allocate 50 meters to each manhole for splicing and racking, hence only 15.9 kilometers would be available for placement.

The Hatfield Model indicates fiber splicing costs of $15: 24 fibers @ $1.60 each. This seems extremely low, particularly under current market conditions.

## Conclusion

We have identified and discussed significant shortcomings in the model. Cumulatively, these shortcomings constitute strong evidence of an unacceptable bias in design that would preclude use of the model in any real world design or cost analysis. These shortcomings also indicate a weak design embedded within the software, a weakness than probably could not be overcome by simply recompiling the code or transferring the underlying design to another software application package.

Perhaps the greatest shortcoming is the model's failure to incorporate contemporary thinking about feeder design in a "green fields" situation. The model does recognize that the known wire center locations could be the basis of a SONET system. In Russia, Kuwait, Malaysia, and numerous other countries in which deregulation has occurred, the ELECs are building their competitive networks using Synchronous Digital Hierarchy ("SDH") technology that is essentially identical (for the purposes of this discussion) to SONET.

We consider this to be a significant omission because it indicates a lack of forward looking thinking in design. The failure of the model's designers to consider the use of SONET design principles for construction of the feeder portion of the network is perplexing and inappropriate. We believe this feature should be an integral part of design for any forward looking network because of its low cost, resiliency, and provision of quality supported services, as well as its capacity for enhanced services.

## Appendix A. Excerpt from the Joint Board Recommendations to the FCC (Paragraph 277)[18]

"The Joint Board recommends that the Commission use the following criteria to evaluate the reasonableness of any proxy model.

(1) Technology assumed in the model should be the least-cost, most efficient and reasonable technology for providing the supported services that is currently available for purchase, with the understanding that the models will use the incumbent LEC's wire centers of the loop network for the reasonably foreseeable future.

(2) Any network function or element, such as loop, switching, transport, or signaling, necessary to produce the supported services must have an associated cost.

(3) Only forward-looking costs should be included.

(4) A forward-looking cost of capital and the recovery of capital through economic depreciation expenses must be included.

(5) The model should estimate the cost of providing services for all businesses and households within a geographic region. This includes the provision of multi-line business services to allow the models to reflect the economies of scale associated with the provision of these services.

(6) A reasonable allocation of joint and common costs should be assigned to the costs of supported services. This allocation will ensure the forward-looking costs of providing the supported services do not include an unreasonable share of the joint and common costs incurred in the provision of both supported and unsupported services, e.g., multi-line business and toll services.

(7) The models and all underlying data should be available to all interested parties for review and comment. The data should be verifiable, engineering assumptions reasonable, and outputs plausible

(8) The model should be able to examine and modify the critical assumptions and engineering principles. It should also allow for different costs of capital, depreciation and expenses for different facilities, functions, of elements."

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[18] Federal-State Joint Board on Universal Service, CC Docket 96-45, *Recommended Decision*, November 8, 1996, ("Joint Board Decision"), page 9, paragraph 277.

## Appendix B. Credentials of Principal Investigator

# ROBERT F. AUSTIN, PH.D.

1340 Gulf Boulevard, #18-C
Clearwater, FL 34630-2810 USA
E-mail: docbo@aol.com

Voice: +1-813-595-7204
FAX: +1-813-595-7204
Cellular: +1-813-403-0530

## Professional Experience

### *Austin Communications Education Services, Incorporated*

1340 Gulf Boulevard, #18-C, Clearwater, FL 34630-2810 USA

*July, 1991 - Present*: President. Responsible for GIS training, consulting, system design and corporate management. Clients include Andersen Consulting Kuala Lumpur, Antigua Telephones (APUA), Andrew Corporation, Barbados Telephone, C3, Cadtel Systems, CSC, Edmonton Telephones, Generation 5 Technology, GeoVision, Kancom, Lambda Tech International, Macomnet, Mercator Corporation, Metrocom, Pacific Bell, Rascom, Ramsatcom, SaskTel, Price Technical Services, Sibtelecom, Telebras CPqD, TIME Telekom (TIME Quantum Technology), and the United State Telephone Association (USTA).

*March, 1988 - July, 1991:* Executive Vice President. Responsible for corporate management and operations; AM/FM/GIS system design and consulting; training classes/seminars in AM/FM/GIS. Clients include AT&T, MCI, and Sprint; Bell, United, General, Alltel, Centel, LCTX, and other operating companies; hardware/software manufacturers; and service bureaus.

### *Mercator Corporation*

652 Avenida Munoz Rivera, El Monte Mall, Tercer Piso, Suite 1, Hato Rey, PR 00918-4149, USA

*August, 1996 - Present.* President. Responsible for corporate management, training, marketing and consulting. Clients include Government of Puerto Rico (Centro de Recaudación de Ingresos Municipales) and Government of Paraguay (World Bank).

### *Andrew Corporation*

10500 West 153rd Street, Orland Park, IL 60462-3071, USA

**Andrew Telecom Networks**, 2425 North Central Expressway, Richardson, TX 75080, USA

*June, 1994 - September, 1994*: Director. Responsible for new business development, strategic planning, and technical training in a start-up engineering services division.

**Andrew International,** Academy of Sciences, 32A Leninski Prospekt, Moscow, 117334, Russian Federation

*January, 1993 - May, 1994*: Director, Applications Engineering. Responsible for information systems design and development for several Russian-American joint ventures. Systems designed and/or specified for purchase included office automation, international electronic mail, automated mapping/facilities management, and multi-currency accounting. Also responsible for network product sales, new project bid preparation, and on-going information systems support.

### *Baystar Service Corporation/CDI Corporation*

311 Park Place Boulevard, Suite 650, Clearwater, FL 34619, USA [CDI Corporation acquired Baystar Service Corporation in June, 1989.]

*July, 1989 - July, 1991*: Vice President, Automated Mapping and Facilities Management Systems. Responsible for all aspects of corporate AM/FM/GIS activity. Clients included Advanced Computer Graphics, Ameritech Services, C3, CFW Telephone, Coastal Utilities, GeoTechnology International, GTE Data Services, GTE Florida, GTE Network Operations Planning, Lufkin-Conroe Telephone Exchange, MCI, MSE Corporation, New England Telephone, New Zealand Telecom, and Southwestern Bell Telephone.

*September, 1987 - June, 1989*: Director, Automated Mapping and Facilities Management Systems. Responsible for digital cartography marketing, system design, consultation, and project management. Clients included AT&T-EDDS, GTE-Florida, and MCI.

*June, 1986 - September, 1987*: Regional Manager, Dallas/MCI. Responsible for hiring, salary assessment, and supervision of approximately 70 contract staff; AM/FM consulting, marketing and system definition; microcomputer programming for MCI Telecommunications.

*September, 1985 - June, 1986:* Computer Data Systems Consultant. As a consultant to MCI, responsible for defining, designing, and implementing a hardware, software, and data conversion system for automated mapping and facilities management; preparing standards and technical manuals for fiber optic outside plant engineering and construction.

### *Chicago Aerial Survey, Incorporated*

2140 Wolf Rd., Des Plaines, IL 60018-1932 USA

*June, 1984 - August, 1985*: Senior Staff Scientist. Project Manager for digital map conversion project for Southern Bell Telephone Company (PLRMS); managed several raster system projects including J.D. Irving and California Department of Conservation; prepared production reports, technical reports, proposals, and in-house training materials for digital cartography.

### *Geolocator, Incorporated*

412 1/2 W. Walnut, Columbia, MO 65201 USA

*February, 1978 - May, 1984*: President. Industrial site analysis for state and local gov-

ernments and private sector firms; developed site analysis and mapping applications on mainframes and microcomputers.

### *Other Communications Industry-Related Experience*

*Summers, 1969 - 1974*: Telephone and CATV craft work, contracted by Harris-McBurney, Rollins Commserve, Ann Arbor Cable, and Saginaw Cable. Work included aerial cable placement (Journeyman-B), buried cable placement, crew chief, and installation.

## Academic Experience

### *University of Missouri-Columbia,*

Department of Geography, Stewart Hall, Columbia, MO 65211 USA
September, 1977 - August, 1985: Assistant Professor [On leave: 1980-81, 1984-85]
September, 1978 - August, 1980: Chairman of Department
Courses taught: Location Theory, Cartography, Quantitative Methods, Population Geography, Planning, Southeast Asia, World Regional Geography. Other duties included Faculty Council, 1982-1984 (Chair, Student Affairs Committee 1983-84); various university committees; co-sponsor, Geographic Resources Center (a remote sensing and mapping research facility)

### *Oxford Polytechnic*

Dept. of Social Sciences, Headington, Oxford, OX1 0BP UNITED KINGDOM
September, 1980 - May, 1981: Senior Fulbright Fellow (Exchange Professor / Visiting Lecturer)
Courses Taught: Human Geography, Southeast Asia, Political Geography

### *Guest Lectures*

Lawrence Technological University, 1992; Loughborough University of Technology, 1981; University of Oxford, 1981 (Visiting Senior Fellow); Center for International Briefing, 1980, 1981; University of Washington, 1978; Institute for Southeast Asian Studies, 1976

## Education

Ph.D., 1977, University of Michigan, Ann Arbor, MI (Geography)
M.A., 1974, University of Michigan, Ann Arbor, MI (Geography)
B.A., 1972, University of Michigan, Ann Arbor, MI (Geography/Southeast Asian Studies)
Diploma, 1968, Southfield High School, Southfield, MI

## International Work Experience

1996 Malaysia, Puerto Rico (consulting, project management, training)
1995 Brazil, Malaysia, Antigua (consulting, project management, lecturing and training)
1994 Russia, United Kingdom, Ukraine, Colombia, Thailand (project management, consulting, lecturing and training)
1993 Barbados, Russia (consulting, lecturing and training)
1992 Australia, Brazil, Canada, New Zealand (consulting, lecturing and training)
1991 Australia, United Kingdom, Canada, Barbados (consulting, lecturing and training)
1980-81 United Kingdom, Netherlands (college lecturing)
1975-76 United Kingdom, Singapore, Malaysia, Brunei, Thailand (Ph.D. research)

## Technical Training

Enghouse Systems Geonet Training, 1995
Andrew Corporation Mid-Range Products and Network Products Training, 1994
SUN Microsystems Seminar Series, 1990
DEWS AMS/GIS Operator Training, GeoVision, 1990
Utilities Facilities Management (FRAMME-SM), Intergraph, 1987
Basic Transmission Concepts, Austin Communications Education Services, 1987
Numerical Analysis of Remote Sensing Data, Purdue University Laboratory for Applications of Remote Sensing, 1982
Short Course on Demography, National Science Foundation, 1977
Workshop in Photography, National Geographic Society, 1973
Post-graduate courses in mathematics and computer science, University of Missouri, 1977-84

## Professional Associations

American Congress on Surveying and Mapping (ACA)
Association of American Geographers
Chair, Southeast Asia Division, Asian Specialty Group, 1984-86
AM/FM International
Publications Committee, 1986-87; Standards Committee, 1986-87; Conference Committee (Seminars), Conference XI, 1988; Conference Principal and Co-Chairman, Conference XIII, 1990; Committee for Asia and the Pacific, Chairman 1990-92; Annual Conference Chairman, Conference XIV, 1991; Board of Directors, 1990-91, 1993; Australasian Conference Co-Chairman, 1991; Life Cycle Seminar, AURISA 1992 (Gold Coast, Australia); various seminars
Malaysian Branch, Royal Asiatic Society (Life Member)
Institute of Electrical And Electronics Engineers (Member)

## Other Professional Activities

Advisory Board, International Society of Spatial Sciences (a division of Community Systems Foundation), 1995 - present
Editorial Board, *Solstice*, 1990 - present
Editorial Board, *Equinox*, 1989 - present
Editorial Board, Institute of Mathematical Geography, 1986 - present

## Awards

1992 AM/FM International Speaker Excellence Award
1992 Who's Who In Emerging Leaders in America (first inclusion)
1991 Pe. Roberto Landell de Moura Medal, CPqD Telebras, Brazil
1991 Who's Who In American Business Leaders (first inclusion)
1990 Who's Who In The Computer Industry (first inclusion)
1990 Who's Who In The South And Southwest (first inclusion)

## Personal

Date of Birth: May 17, 1950
Citizenship: United States of America

## Publications

"Time Telekom's Network Inventory System: AM/FM/GIS In The Big Durian " (with Chin C.M.), *AM/FM International Automated Mapping/Facilities Management Conference XX Proceedings*, 1997 (forthcoming).

"Mapping Malaysia's Telecommunications Infrastructure: GIS at TIME Telecommunications" (with Chin C.M.), *GIS Asia Pacific*, 2:3, 34-38, 1996 (June).

"China: Spring Break '96," *KL American*, 24-27,1996 (June/July).

"The Laws Of Project Management For Automated Record Systems," *Geo Info Systems Magazine*, 4:4, 1995 (April).

"'Estado Del Arte' Y Tendencias De La Tecnologia SIG A Nivel Mundial" ("State Of The Art Of GIS Technology"), *Plan De Accion Para La Implantacion De Las Tecnologias -- SIG AM/FM -- En Colombia: Diagnostico Y Recomendaciones*, CINTEL Seminario Internacional Santiago de Cali, Agosto 31 - Septiembre 1y 2 de 1994, 33-42 (digital publication), 1994.

"GIS for Fiber Loop Communications Systems: A Russian Case Study," *AM/FM International Automated Mapping/Facilities Management Conference XVII Proceedings*, 232-239, 1994; edited version published in *Intercarto Conference: GIS for Environmental Studies and Mapping Conference Proceedings* (Moscow State University), 79-83, 1994.

*Practical Handbook of Digital Mapping* (Specialist Associate Editor) (with S.L. Arlinghaus, Editor-in-Chief, and W.C. Arlinghaus, W.D. Drake, and J.D. Nystuen, Associate Editors), CRC Press, 1994.

"Training Doesn't Cost: It Pays," *AM/FM International Automated Mapping/Facilities Management Conference XVI Proceedings*, 399-408, 1993.

"Principles Of Ruggedization, Or Field Access: The Last Piece In The Puzzle," *AM/FM International Automated Mapping/Facilities Management Conference XV Proceedings*, 51-60, 1992.

"Digital Maps And Data Bases Constructed From Cartographic Sources Versus Mechanically Drafted Sources: A Perspective On Aesthetics Versus Accuracy," *Solstice*, II:2, 31-37, 1991 (December 21).

"AM/FM Needs Of The 1990's", *Telephony*, 220:11, 124-128, 1991 (March 18).

"GEMS In The Pines: GIS At Lufkin-Conroe Telephone Exchange," (with P. Singletary), *Geo Info Systems Magazine*, 1:2, 22-29, 1991 (February).

"AM/FM At Coastal Utilities: A Profile In Development," *Outside Plant Magazine*, 29-33, 1989 (November).

"Data Bases As The Basis For Geographical Information Systems: A Perspective," *GIS/LIS '89 Conference Proceedings*, 123-133, 1989.

"GIS/LIS In The Long Distance Telecommunications Industry," *Third International GIS/LIS Conference (GIS/LIS '88) Proceedings*, 266-272, 1988.

"Praxis as Teratism in Digital Cartography: GIS and AM/FM for the Long Distance Telecommunications Industry," *American Congress on Surveying and Mapping 1988 Fall Convention Proceedings*, 198-205, 1988.

"Some Recent Developments In AM/FM Systems For Long Distance Carriers," *AM/FM International Automated Mapping/Facilities Management Conference XI Proceedings*, 21-31, 1988.

"Outside Plant Record Management For Fiber Optic Networks: The MIRACLES AM/FM

Project At MCI," (with C.H. Sauer III), *AM/FM International Automated Mapping/Facilities Management Conference X Proceedings*, 17-27, 1987.

*A Historical Gazetteer Of Southeast Asia*, Monograph No. 4, Institute of Mathematical Geography Monograph Series, Ann Arbor: Michigan Document Services, Inc., 1986.

"Service Ace," [letter] *Telephony*, 210:5, 12, 1986 (February 3).

"Raster/Vector Systems In A Production Environment," *URISA and Regional Information Systems Association Conference Papers*, 4, 203-211, 1985.

"Making Maps With Databases," *Telephony*, 208:19, 34-39, 1985 (May 13).

"Raster Systems In A Production Environment," *Design Graphics World*, 9:3, 10-15, 1985.

"An 'Everyday Atlas'," *Journal of Geography*, 83:4, 173-174, 1984.

"Measuring and Comparing Two-Dimensional Shapes," in Gaile, G.L. and Willmott, C.J. (editors), *Spatial Statistics and Models*, Dordrecht: D. Reidel Publishing, 293-312, 1984.

*Bibliography Of Measures Of Spatial Shape*, Vance Bibliographies No. P-1142 (Public Administration Series), Monticello, IL, 18 pp., 1983.

"Reply To Phillips," *The Professional Geographer*, 35:2, 195-196, 1983.

*Cartography* (independent study course book, University of Missouri, Center for Independent Study), 1983.

"A Definition And Estimate Of Temporal Area," *The Professional Geographer*, 34:3, 297-304, 1982.

"On Contiguity, Contact Number And Compactness (Reply To Boots And Blair)," *Area*, 14:2, 127-131, 1982.

"Comment On 'Undocumented Migration From Mexico: Some Geographical Questions'," *Annals of the Association of American Geographers*, 72:4, 559-560, 1982.

"The Compactness Of Missouri's Counties," (with T. Dowell) *Transactions of the Missouri Academy of Science*, 16, 127-130, 1982.

"The Shape Of West Malaysia's Districts," *Area*, 13:2, 145-150, 1981.

"Measures Of Population Concentration," *Oxford Polytechnic Geography Discussion*