BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

Comprehensive Review of the Revenue Requirements and Rate Stabilization Plan of Southern Bell Telephone & Telegraph Company	)))))	Docket No. 920260-TL Filed: November 16, 1992

CONFIDENTIAL

DECLASSIFIED

DIRECT TESTIMONY

OF

MICHAEL L. BROSCH

On Behalf of the Citizens of The State of Florida

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PREPARED TESTIMONY
OF
MICHAEL L. BROSCH

Q. Please state your name and business address.

A. My name is Michael L. Brosch. My business address is 740 North Blue Parkway, Suite 204, Lee's Summit, Missouri 64063.

Q. What is your present occupation?

A. I am a principal of Dittmer, Brosch and Associates, Inc. The firm's business and my responsibilities are primarily related to special services work for utility regulatory clients, including rate case reviews, cost of service analyses, jurisdictional and class cost allocations, financial studies, rate design analyses, and special investigations related to utility operations and ratemaking issues.

Q. Will you summarize your educational background and professional experience in the field of utility regulation?

A. I graduated from the University of Missouri, Kansas City, in 1978 with a Bachelor of Business Administration Degree, majoring in accounting. I hold a CPA

Certificate in the State of Missouri and in the State of Kansas. I am a member of the American Institute of Certified Public Accountants, the Missouri Society of Certified Public Accountants, and the Kansas Society of Certified Public Accountants. From 1978 to 1981, I served as a public utility accountant with the Staff of the Missouri Public Service Commission. While employed by the Missouri Commission, I participated in rate case examinations involving electric, gas, water, steam, transit, and telephone utilities operating in Missouri. My responsibilities in Missouri utility rate case proceedings included analysis and testimony on virtually all facets of public utility revenue requirement determination.

In December, 1981, I accepted a regulatory consultant position with Troupe Kehoe Whiteaker & Kent in its public utility department. While with Troupe Kehoe Whiteaker & Kent, I directed the development and presentation of an in-house training program on public utility income tax accounting concepts and issues. With other firm members, I was involved in the review, analysis, and presentation of a wide range of rate case issues and various other utility management advisory functions for both utility company and regulatory agency clients.

In May of 1983, I commenced employment with Lubow McKay Stevens and Lewis as a senior consultant. While with that firm, I was involved in numerous regulatory proceedings and directed several project teams in the conduct of special projects including the development of a comprehensive lead lag study theory and procedures manual for use by the Ohio Office of the Consumers' Counsel (OCC) and its technical staff. Other special projects that I directed included a detailed analysis of utility holding company formation/ diversification policy issues for the Wisconsin Public Service Commission and a study of electric utility interconnection agreements and related bulk power transactions studies of Ohio electric utilities.

In June of 1985, Dittmer, Brosch and Associates, Inc. was organized. The firm specializes in public utility regulatory and management consulting in the electric, gas, telecommunications, water, and wastewater industries. As a principal of the firm, I am responsible for the supervision and conduct of the firm's various regulatory projects currently in process.

I have testified before utility regulatory agencies in Arizona, Arkansas, Florida, Hawaii, Illinois, Indiana, Kansas, Michigan, Missouri, Ohio, Oklahoma, Washington and Wisconsin in regulatory proceedings involving electric, gas, telephone, water, sewer, transit, and steam utilities.

Q. What experience have you had in analyzing and quantifying revenue requirements for telephone utilities in general, and Bell operating companies in particular?

A. I have been involved in many telephone rate cases involving Bell operating companies, major independent telephone companies and small investor owned and cooperative telephone companies. I have testified regarding telecommunications issues in multiple jurisdictions on a wide variety of issues.

With respect to Bell companies, I have participated in multiple pre and post-divestiture rate proceedings in Arizona, Indiana, Oklahoma, Washington, Wyoming and several cases in Missouri. Moreover, I have analyzed and addressed BELLCORE and regional holding company affiliated relationships with regulated Bell telephone subsidiaries several times in certain of these jurisdictions over the past decade.

Q. What functional areas of the Florida Office of the Public Counsel (OPC) case are you directly responsible for?

A. I have reviewed and will sponsor testimony addressing Southern Bell's transactions with certain affiliated companies, including the parent, BellSouth Corporation headquarters (BSC-HQ) and Bell Communications Research, Inc. (BELLCORE). I also examined one segment of the Southern Bell affiliate, BellSouth Services', Science and Technology (S&T) entity.. My analysis for this proceeding used the Company's filing as a starting point. Since Southern Bell made certain affiliate disallowances in its own prefiled case, I propose additional adjustments as required to properly restate test year affiliate transactions to a reasonable level for use in quantifying Southern Bell's revenue requirements.

Q. What are the general types of adjustments which are described in your testimony?

A. I propose adjustments to restate charges to Southern Bell from three of the principal affiliates doing business with Southern Bell, BSC-HQ (parent), BELLCORE (research and development services) and BellSouth Services' Science and Technology (S&T) organization.

BellSouth Corporation headquarters (BSC-HQ), Southern Bell's parent corporation, has a large centralized corporate staff which is organized into discrete responsibility codes (RC's). Each RC incurs labor and non-labor costs, most of which are assigned or allocated among the BellSouth subsidiaries, including Southern Bell. I propose adjustments to Southern Bell's proposed recovery of such parent company costs to eliminate certain parent-ownership costs not properly recovered from ratepayers, as well as to disallow certain proprietary types of costs which should be disallowed if incurred directly by Southern Bell.

Q. In general, why must regulators be concerned with affiliated interest transactions of regulated utilities, such as Southern Bell?

A. Utilities which have transactions with affiliates introduce new complexity and responsibility into the regulatory process. Complexity is obvious throughout the diverse departments and activities of numerous affiliates individually and collectively transacting with the regulated entity as well as among multiple affiliates, creating pools of costs, some of which are ultimately charged to regulated ratepayers. Additional regulatory responsibility arises from the potential for abusive cost attribution to regulated ratepayers in a variety of ways.

Q. What potential forms of abuse are existent within the affiliated interest relationships of regulated telephone companies?

A. Examples of generic regulatory concerns with affiliated transactions of rate-regulated utilities include:

1) Incurrence of objectionable expenses by an affiliate which are partially allocated to the utility. Examples include contributions, lobbying, antitrust and advertising.

2) Improper allocation or assignment methodologies for affiliate costs which may subsidize unregulated business segments.

3) Pricing goods/service bought by the regulated utility from affiliates at prices which yield unreasonably high returns.

4) Pricing goods/services sold by the regulated utility to affiliates at prices less than the higher of the utility's costs or market values.

5) Uncompensated sharing of utility intangible assets such as personnel expertise, intellectual properties, credit worthiness and purchasing power.

6) Charging the regulated utility for goods or services not required to provide utility service, such as redundant expenses, corporate ownership costs, merger/acquisition costs and unnecessarily extravagant expenditures.

7) Contrived financing or operating arrangements between utilities and affiliates which attribute higher costs to the utility or attribute profitable business segments or functions away from the utility to its affiliates.

8) Other affiliated interest abuses, such as parent company debt leveraging, risk shifting and capital structure or dividend policy manipulation.

Q. Do you mean to imply by this list of potential abuses and regulatory concerns that all affiliated arrangements of regulated utilities are unreasonable?

A. No. Many of the utility-affiliate arrangements I have studied are advantageous to the utility and make good business sense as the most efficient means to provide necessary goods and services. However, all significant utility transactions with affiliates must be reviewed with a strong appreciation of the potential problems and general concerns arising from these arrangements. My conclusion with respect to BSC-HQ and BELLCORE is that the majority of charges to Southern Bell are reasonable for inclusion within regulated revenue requirements.

Q. Do the affiliated transactions of Southern Bell raise issues in some of the areas of concern you listed?

A. Yes. The remainder of my testimony discusses certain issues arising from Southern Bell's transactions with affiliates which, in my opinion, merit consideration by the Commission in this Docket. Since my responsibilities were limited to Southern Bell's transactions with BSC-HQ, the parent company, and BELLCORE, I have no conclusions with respect to Southern Bell transactions with other affiliates.

Q. How have your efforts been coordinated with the presentation of Mr. Randy Allen, OPC's primary revenue requirements witness?

A. I have discussed my proposed adjustments with Mr. Allen and have forwarded appropriate amounts to him for inclusion in the total revenue requirement calculations that he sponsors. To the extent Mr. Allen sponsors revenue requirement calculations for test periods other than 1991, I recommended that my adjustments be restated in proportion to any escalation of gross BSC-HQ or BELLCORE jurisdictional expenses.

Q. How is the remainder of your testimony organized?

A. My testimony is arranged by topical section. The following table serves to index the testimony sections with reference to the related schedules at the end of this volume which I sponsor:

Topic	Testimony Page	Exhibit
BSC-HQ (Parent) Ownership Costs	11	MLB-1
BSC-HQ Proprietary Disallowances. . . .	35	MLB-1
BELLCORE/BellSouth Services-Science & Technology	48	MLB-2

BELLSOUTH CORPORATION PARENT OWNERSHIP COSTS

Q. What is the overall form of organization of BellSouth Corporation and how does Southern Bell fit within the organization?

A. BellSouth Corporation was one of seven Regional Bell Operating Companies (RBOC's) created at divestiture to own and operate the previously integrated AT&T Bell operating companies. Southern Bell and South Central Bell were organized as subsidiaries of BellSouth Corporation at divestiture, with Southern Bell continuing to provide regulated Florida intrastate telephone services under BellSouth ownership and control.

Effective at year-end 1991, Southern Bell's name was changed to BellSouth Telecommunications, Inc. and at that time South Central Bell, as well as BellSouth Services Incorporated (a jointly owned service subsidiary of Southern Bell and South Central Bell), were merged into this renamed entity. However, BellSouth Telecommunications continues to use the names of Southern Bell and South Central Bell for various purposes. I will use "Southern Bell" herein to refer to the regulated telephone operations of BellSouth Corporation, subject to FPSC jurisdiction. I have attached as Attachment MLB-1 a copy of the BellSouth Corporate Structure organizational chart from the Company's FCC Cost Allocation Manual to illustrate the relationship of BSC-HQ to BellSouth Telecommunications (doing business as Southern Bell and South Central Bell) as well as the multitude of diversified domestic and foreign subsidiaries controlled by BellSouth Corporation.

Q. Does BSC-HQ incur labor and non-labor departmental costs for centralized corporate services which it charges to various subsidiaries including Southern Bell?

A. Yes. According to Southern Bell's FCC Cost Allocation Manual, services provided to it by BSC-HQ include:

- Financial services, such as securing capital, maintaining investor relations, administrating pension fund, preparing consolidated financial reports, providing budget assistance and economic forecasts.
- Regional planning services such as corporate, strategic marketing and technical (including development).
- Personnel services related to labor relations, relocation, wages, salaries and assessment.
- Legal assistance on taxes, antitrust and federal matters.

- Public affairs involving federal regulatory and federal legislative activities.
- Public relations related to financial advertising and media information.
- Accounting and tax services such as internal corporate reports, consolidated tax returns, accounting policies rulings and interpretations and internal audit policy.
- Executive Support
- Security

Q. What level of BSC-HQ costs are included within Southern Bell's Florida Intrastate expenses in its minimum filing requirements?

A. Exhibit _____(MLB-1) summarizes Southern Bell's test period Florida Intrastate BSC-HQ expenses by Department. Column D of this Schedule sets forth the unadjusted Florida Intrastate BSC-HQ corporate services expenses of $19.5 million per books. Column E reflects Southern Bell's MFR adjustment to eliminate certain of the BSC-HQ and other affiliate charges in the total amount of $1.9 million (See MFR Schedule A-66, page 23). After the

Company's adjustment, the remaining Florida Intrastate share of BSC-HQ corporate services expense the Company seeks to recover total $17.8 million. In addition to corporate services, BSC-HQ also bills Southern Bell for a variety of specific project costs. However, these test period intrastate charges totaled only $0.8 million for all project costs.

Q. Does Southern Bell's parent corporation, BellSouth Corporation (BSC-HQ), act in dual capacity, serving as both a management service company and as corporate owner of Southern Bell and its other subsidiaries?

A. Yes. BSC owns all of the outstanding common stock of Southern Bell as well as significant financial interests in a wide variety of diversified businesses, including domestic cellular telephone services, foreign cellular systems, domestic and international paging services, directory advertising and publishing, CPE sales and leasing, software creation and sales, graphics and printing services, Australian telecommunications and other business operations. Therefore, BSC exists as both a parent/holding company and a service company, BSC has the same interests as any institutional investor managing a diverse portfolio of businesses. The duality of purpose comes into play where BellSouth acts as more than a passive equity investor in Southern Bell, by virtue of its self-appointment as management advisor to the subsidiary telephone companies. In its dual role of owner and advisor, BellSouth sells management advice and assistance to the subsidiary telephone company and other subsidiaries while simultaneously protecting its ownership interest in such subsidiaries.

Q. Have you analyzed the specific functions and related costs within the BSC-HQ billings to Southern Bell?

A. Yes. My examination focused upon the nature of activities within each of the BSC-HQ responsibility areas and the amount of costs incurred within each RC, as well as the allocation of same among BSC subsidiaries. I examined BSC-HQ organizational charts, written job descriptions, detailed descriptions of departmental activities and benefits, and examples of work product emanating from various BSC-HQ departments.

Q. How are the BSC-HQ billings for General Services and Licenses costs accumulated and charged to Southern Bell and other affiliated companies?

A. BSC-HQ is organized into responsibility codes (RC's) for which all salaries and non-labor costs are accumulated. Each RC has a defined functional role within the overall management framework of BellSouth Corporation. BSC, as parent corporation, contains departmental management resources to control and direct its portfolio of investments in its subsidiary company business segments, including the regulated telecommunications segment, as well as the diversified BellSouth Enterprises segment.

Each RC accumulates its expenses for assignment or allocation to designated affiliate beneficiaries. The basis of allocation is prescribed by BSC-HQ management with the intent being to causally and systematically assign costs to the business entities receiving benefit from the RC's actions. The allocated costs from each RC are accumulated and billed to the telephone companies and other subsidiaries of BSC on a monthly basis.

Q. Does BSC act as both advisor and director of the telephone subsidiaries, including Southern Bell?

A. Yes. BSC serves both an advisory staff function as well as a line management control function over the regulated telephone operations of Southern Bell and other subsidiaries. In contrast, telephone company management has authority over and responsibility for operational issues, acting within the operational guidelines and broad policy directives prescribed by the parent organization.

Positions taken on corporate-wide policy issues are under the authority of BSC-HQ. The parent company also controls corporate strategic planning and centralized administrative processes. BSC-HQ guides the business planning done by Southern Bell, oversees the capital and operations budgeting process, establishes expenditure and earnings commitments from regulated telco management and monitors achievements of such plans, budgets and commitments.

Q. You previously indicated ratemaking adjustments to several categories of these BSC-HQ costs which you sponsor. Turning to your first adjustment category, what are the kinds of costs which you characterize as "ownership" which should be disallowed?

A. BSC-HQ costs which I consider to be ownership in nature are those costs which are incurred as a function of BSC in the role of parent company and investor in Southern Bell as well as the other diversified subsidiary companies. Specific examples of ownership costs include the costs of the holding company's senior executive management who are concerned with planning and managing the BellSouth portfolio of diversified business ventures, while providing overall policy guidance and corporate governance over each subsidiary.

Another example of ownership costs are those costs incurred by the BSC-HQ corporate secretary, corporate treasury, corporate planning and certain corporate counsel RC's which are primarily responsible for maintenance of the parent company legal entity and the administration of its corporate responsibilities and external legal affairs, such as Board of Directors of the parent company and the cash management and investment functions which generate below-the-line income for the consolidated BSC organization. Many of these "ownership" costs are duplicative of costs incurred directly by the BSC subsidiaries. For example, corporate Board of Directors fees and expenses, treasury department cash management costs, and corporate secretary activities are duplicative of similar costs incurred directly by the BSC subsidiaries.

Even though there is a duality of purpose, with BSC-HQ acting as both management advisor and parent/owner, the Company's proposed allocation of BSC-incurred costs would cause many parent/ownership costs to be charged to ratepayers, if the FPSC fails to approve the ownership cost disallowance I propose.

Q. If Southern Bell were owned by individual investors, rather than a holding company parent, would such investors be able to recover their ownership costs from regulated ratepayers?

A. No. It is only by virtue of the telephone subsidiary billing mechanism that the problem arises. BSC-HQ is able to recover both the costs of management advice and assistance, as well as the costs it incurs to manage its portfolio of investments in the telephone companies and non-regulated affiliates, through corporate services billings. I propose that the Commission consider the costs associated with BSC oversight and management of its investment in Southern Bell and its other subsidiaries to be properly chargeable against its dividend income stream rather than allocated and recovered from telephone ratepayers.

Q. Does your Exhibit ___(MLB-1) set forth detailed BSC-HQ Florida intrastate amounts by parent Company Department which you propose to disallow as ownership costs?

A. Yes. Column G of Exhibit ___(MLB-1) provides the detailed costs by BSC Department which I propose to disallow as being ownership in nature and not properly recoverable from ratepayers. These amounts are quantified at a Southern Bell-Florida intrastate level. Line 24 of column G represents my total proposed adjustment.

Q. Why have you included the cost of BSC's Chief Executive Officer, its Vice Chairman and other BSC Executive Vice President responsibility codes within your "ownership cost" disallowance category?

A. Senior executive management at BSC-HQ is, at best, only indirectly involved in providing specific detailed technical and management advice and assistance to the telephone company. The roles of these individual executives is primarily oriented to broad BSC strategic policy issues and the promotion of BSC in the most favorable light to the investment community and other public forums.

I believe that the value of the parent's senior most management is realized primarily by the parent, rather than Southern Bell ratepayers, and should not be so heavily allocated to regulated telco ratepayers. Therefore, at column G, line 1 of Exhibit __ MLB-1, I have eliminated one-half of the cost of BSC-HQ's most senior executives, as allocated to Southern Bell.

Q. Do the written position descriptions associated with the four senior-most Bellsouth Corporation executives you would partially disallow support your conclusion that these executives are portfolio managers?

A. Yes. According to written position descriptions for BSC's Chairman, President, and Chief Executive Officer (1 position), the focus of management attention extends far beyond the telephone company's interests:

> <u>Accountability Objective</u> (Basic Function)
>
> To provide leadership to the Board of Directors in carrying out its collective responsibility for the management of the assets, business and affairs of BellSouth Corporation.
>
> To strategically plan, organize, manage and control the total operations of BellSouth Corporation and its subsidiaries in ways that result in the optimum in cost effective service, the required growth in revenues and earnings, and expansion into new international

> markets and new business lines, while maintaining compliance with applicable regulatory guidelines, Board policy standards, and maintenance of a viable existence within the competitive marketplace.
> (2nd Interrogatory, Item No. 34)

Reporting directly to the CEO of the parent Company is BellSouth's Vice Chairman-Finance & Administration, its Executive Vice President-Governmental Affairs, and its Executive Vice President and General Counsel. Other direct reporting positions to the CEO include BellSouth Telecommunications' Chairman, and the President of BellSouth Enterprises. This parent Company reporting structure is illustrated in Attachment MLB-2, a BellSouth Corporation management organization chart received in response to 3rd POD, Item No. 39. Attachment MLB-3 contains written position descriptions for the four senior-most BellSouth executives I propose be treated as parent/ownership costs.

Q. How do the responsibilities of the telephone Company's Chairman and CEO compare with the responsibilities of the parent Company's CEO, Vice-Chairman and Executive VP's?

A. The telephone subsidiary's Chairman and CEO also has overall leadership, planning and management responsibilities comparable to the responsibilities of the BellSouth CEO, except that his focus is upon telephone company operations, rather than global holding company portfolio performance. A written position description for the telephone Company's CEO was provided in response to 2nd Interrogatory, Item No. 35, describing the position as follows:

> Title: Chairman and Chief Executive Officer
>
> Reports To: Chairman, CEO and President of BellSouth Corporation
>
> Provides leadership and overall direction for the planning, management and control of all aspects of BellSouth Telecommunications activities for the effective coordination and integration of the varied and diverse functional elements of the company's operations to produce the required levels of growth in revenue and earnings. Participates in the overall strategic management direction of BellSouth Corporation, thereby contributing

to the overall strategic direction of BellSouth, and representation within BellSouth on behalf of BellSouth Telecommunications.

Q. In your opinion, does the allocation of BSC-HQ senior executive management costs burden ratepayers with excessive and duplicative executive compensation expense?

A. Yes. In the 1991 test period, Florida ratepayers are asked to pay for three layers of generously compensated senior executive management. The compensation of the most highly compensated executives of Southern Bell, BellSouth Services, Inc., and BellSouth Corporation in 1991 were as follows:

	Top 5 Executive Compensation		
	High	Low	Average
Southern Bell Executives	771,170	396,373	566,814
BellSouth Services Executives	1,788,659	336,392	744,614
BellSouth (parent) Executives	1,355,500	418,500	684,833

I believe that my proposed 50 percent disallowance of BSC-HQ costs is conservative in that it serves to reduce charges to ratepayers for only the third layer of redundant senior executive management.

Q. Is there additional written evidence that the executive management of the parent Company perceives its portfolio to be much broader than the core telephone business of Southern Bell?

A. Yes. Many of the written work products I have reviewed indicate BellSouth's emphasis on global diversification and the efforts of senior executive management in planning and executing such diversification. I have appended Attachment MLB-4 to my testimony to illustrate, through the statements of BellSouth's CEO, Mr. John Clendenin, the direction and scope of the parent Company's strategic planning and to illustrate one of the functions of the CEO in representing BellSouth in the investment community.

Q. Why have you recommended a 50 percent disallowance of BSC-HQ senior executives, rather than 100 percent disallowance?

A. I believe that Florida ratepayers receive little, if any, direct tangible benefit from the efforts of the parent

Company's CEO, Vice-Chairman and EVP's. However, to add additional conservatism to my proposed adjustment, recognizing the difficulties in evaluating such issues, I have reduced the adjustment to 50 percent. In addition, disallowance of only 50 percent of parent/holding company ownership costs is consistent with Florida PSC precedent.

I would note that Southern Bell's adjustment to disallow certain affiliate lobbying costs excludes a portion of costs for the BSC-HQ EVP-Government Affairs. My adjustment is additive to Southern Bell's adjustment.

Q. For what reasons do you propose disallowance of 50 percent of BSC-HQ's Corporate Planning Department as representing "ownership costs"?

A. This BSC department is involved with strategic planning, strategic issues analysis and the identification and analysis of parent Company business opportunities in which BellSouth may be able to profitably invest resources. Even though new business development and new technology deployment can occur either through new product/service introductions within existing BellSouth subsidiary entities <u>or</u> through traditional mergers and acquisitions, the cost of Corporate Planning analysis toward refinement of the parent's portfolio of telecommunications industry products and services is an investor function, properly recovered out of the dividend income stream realized by the parent.

Q. Does the BSC-HQ Corporate Planning Department develop economic and financial forecasts and data bases for use in the parent Company's planning and strategic management processes?

A. Yes. In addition, Corporate Planning develops mathematical simulation models of Bellsouth financial performance for use in the Corporation's financial planning and financial strategy processes. Corporate Planning coordinates the preparation of financial and strategic plans and budgets from the subsidiaries and practices portfolio management by studying, from a consolidated viewpoint, changes to BellSouth's financial value from alternative resource allocations. (3rd POD, Item No. 41)

Q. Does the Company admit that there is an element of redundancy and overlap in the mission and strategic planning of the parent entity compared with the telephone company?

A. In response to Citizen's 9th Interrogatory, Item No. 231, the Company contrasted the mission and planning of the two entities as:

> BellSouth Corporation (BSC) is a holding company responsible for establishing the overall mission, goals, strategic direction and overall guidelines for the total enterprise. BSC has operations other than BellSouth Telecommunications (BST) which cover different product/service markets and more expansive geographic markets than the "local" nine state, franchise service area. As a result, BSC's mission and goals must and do encompass the activities of all of its investments in the telecommunications and information industry.
>
> At the same time, however, BellSouth Telecommunications, a wholly-owned subsidiary of BellSouth Corporation, is responsible for establishing its own specific mission and specific goals consistent with and complementary to the overall mission of BellSouth Corporation. Consequently, while the mission and goals of BellSouth Telecommunications complement and support the overall mission and goals of BellSouth Corporation, they do differ for these reasons.

Q. What internal capabilities exist within Southern Bell to conduct Corporate and Financial Planning without dependence upon BSC-HQ for technical or administrative assistance/services?

A. According to the Company's response to 15th Interrogatory, Item No. 386:

> "BellSouth Telecommunications (Southern Bell) maintains a Planning Staff in the Executive Department which coordinates the Corporate Planning activities of the various functional departments. Each of the Functional departments maintains a Staff responsible for developing functional corporate plans and coordinating their implementation. Financial Planning for BellSouth Telecommunications (Southern Bell) is performed by various Headquarters Organizations under the direction of the Financial Management and Analysis Staff. Collectively, these organizations have all of the capabilities needed to perform financial Planing [sic] Functions for the Company."

Q. Referring next to the BSC-HQ Treasury Department, why have you classified 50 percent of BellSouth's Assistant Treasurer-Cash Management costs, as charged to Southern Bell-Florida Intrastate, to be "ownership costs" and thereby disallowed?

A. The BellSouth parent Treasury Department performs a broad range of activities including pension administration, investor relations, cash management and financing support. I do not oppose BellSouth's allocation of pension trust administration and investor relations costs within the treasury function because centralization of these activities at BSC-HQ should allow Southern Bell to avoid direct incurrence of such costs. However, those portions of the parent company's treasury function which include the management of BellSouth consolidated cash, investments and borrowings are appropriately considered ownership costs. Furthermore, BellSouth's efforts to maximize the profitable investment of available cash from Southern Bell and other domestic and foreign subsidiaries produces below-the-line income not credited to ratepayers. Therefore, the costs of centralized cash management should not be charged to Southern Bell ratepayers.

Similarly, the administration of banking relations for the reconciliation of cash books and bank registers and the development of cash forecasts is an entity cost any holding company investor would engage in and absorb out of the resultant dividend income stream. For these reasons, I propose disallowance of one half of the cash management function within the overall Treasury Department costs allocable to Southern Bell in Florida. This narrowly focused disallowance represents only about 28 percent of the total BSC-HQ treasury charges to Florida intrastate operations.

Q. What internal capabilities exist within Southern Bell to develop and coordinate cash forecasts without dependence upon BSC-HQ for technical or administrative assistance/services?

A. According to the Company's response to 15th Interrogatory, Item No. 379:

> "BST develops and coordinates its cash forecasts without dependence upon BSC-HQ.
>
> BST developed its own cash forecast procedures, collects and analyzes its own data, and uses PC spreadsheets designed locally. For information purposes, BST provides BSC-HQ with estimated external financing requirements."

Q. What internal capabilities exist within Southern Bell to coordinate banking relations without dependence upon BSC-HQ for technical or administrative assistance/service?

A. According to the Company's response to 15th Interrogatory Item No. 380:

> "BST coordinates its own banking relations without dependence upon BSC-HQ.
>
> BST develops and maintains its own banking relationships, determines services required, negotiates services and fee structures, tracks bank performance, contracts with banks and dissolves relationships as needed.
>
> BSC-HQ puts together reports on all BSC banking relationships and shares this report with BST."

Clearly, there is a concern with respect to redundancy in the treasury functions of Southern Bell and BSC-HQ, which is partially remedied by my proposed adjustment.

Q. Do you consider the BellSouth Corporation Assistant Secretary, who is responsible for BellSouth Board of Directors Support, to be an ownership cost properly absorbed by the parent, rather than allocated to BellSouth's subsidiaries?

A. Yes. BellSouth's Assistant Secretary provides administrative and research support for the BellSouth Board and committee meetings. This RC's activities support the BellSouth parent legal entity and its control over subsidiary companies and is properly considered an ownership cost. Moreover, the Assistant Secretary activities are redundant in light of the legal obligation of each subsidiary to perform similar functions as a separate legal entity. For these reasons I have disallowed 50 percent of the BellSouth Assistant Secretary dollars charged to Southern Bell-Florida.

Q. What is the total amount and percentage of BSC-HQ costs charged to Southern Bell-Florida Intrastate operations which you propose to disallow as ownership in nature?

A. Total test period BSC-HQ jurisdictional costs charged to Southern Bell which I believe are ownership costs, properly disallowed by the Commission, can be summarized as follows:

BSC-HQ Department Title	1991 Total BSC-HQ $	Total Charged to Florida Intrastate$	Proposed Disallowed Ownership
Executive Mgmt. + CEO	$16,960,449	$1,415,300	$ 429,012
Corporate Planning	4,559,009	893,300	446,650
Corporate Treasury, Cash Mgmt. & Other	14,879,176	2,107,700	590,148
Corporate Secretary/Corp. Counsel	5,196,259	730,600	110,609
Total Amounts	$41,594,893	$5,146,900	$1,576,419
Public Counsel Proposed Disallowance			$1,576,419

The $1,576,419 of BSC-HQ allocated cost I would disallow as ownership costs represent only approximately 8 percent of the total of $19.5 million BSC-HQ costs allocated to Southern Bell-Florida Intrastate operations, in the projected 1991 test year. Note that these amounts tie to Exhibit ____(MLB-1), columns G and D.

BELLSOUTH CORPORATION PROPRIETARY DISALLOWANCES

Q. Has Southern Bell recognized the need to disallow certain of the costs allocated to Florida intrastate operations by BSC-HQ?

A. Yes. The Company included its affiliate disallowance adjustment at MFR Schedule A-6b, page 23, to disallow $1.7 million of BSC-HQ charges for contributions, advertising, lobbying/liaison, memberships/dues and the BellSouth Golf Classic. These costs represent typical costs the proprietor of a business might choose to incur, which are not of a nature that is necessary or essential to provide regulated services or of direct tangible benefit to ratepayers. For this reason, I refer to such costs as proprietary disallowances and recommend that the Commission treat them the same as they would be treated if incurred directly by Southern Bell.

Q. Do you propose further disallowances of BSC-incurred expenses, beyond Southern Bell's proposed adjustment, because of the specific nature of such costs?

A. Yes. In addition to, the ownership cost adjustment previously described, I propose that certain specific costs incurred by BSC-HQ and allocated to Southern Bell-Florida be disallowed because such costs, if incurred directly by Southern Bell, are not properly allowed for ratemaking purposes. These proprietary disallowances would include the BSC-HQ legal costs incurred to defend and support BellSouth positions in antitrust and Modified Final Judgment (MFJ) matters, the remaining costs of corporate advertising not disallowed by Southern Bell's own adjustment, the BSC-HQ corporate affairs department not already disallowed by Southern Bell and the costs of BellSouth DC Public Relations.

Q. What are the BellSouth Corporation antitrust and MFJ legal costs you propose to disallow for ratemaking purposes?

A. I have considered the costs within BSC-HQ Responsibility Code H61300 and a pro-rata share of legal support staff (RC 61170) to be antitrust and MFJ legal costs (11th Int. No. 275 and 3rd POD, No. 41). According to BSC-HQ's work activity description for these lawyers, the functions performed include:

- **Antitrust and Modified Final Judgment**
- Represent the subsidiaries before the MFJ Court.

- Review, analyze and interpret court orders and decisions.
- Review and analyze pleadings filed by others before the Court.
- Represent the subsidiaries before the Court of Appeals on MFJ and antitrust matters.
- Provide legal advice to BellSouth management and the subsidiaries regarding the MFJ.
- Provide antitrust advice to BellSouth management and the subsidiaries.
- Represent BellSouth in antitrust cases.
- Develop and conduct antitrust compliance seminars.

Q. Why should the parent Company's legal representation in antitrust cases not be funded by ratepayers?

A. I have disallowed antitrust defense costs and damage awards because such costs do not generally arise from the provision of regulated, tariffed telephone services, and because BSC-HQ has failed to adequately describe the nature of such charges. In the present case, BSC-HQ was asked what antitrust cases presently involve BellSouth for which BSC-HQ incurs and allocates costs to Southern Bell (9th INT. No. 241). The Company's response listed four individual cases, two of which named Southern Bell as respondent. However, in response to 13th Interrogatory Number 330, The Company responded, "BSC-HQ did not bill any costs to Southern Bell during 1991 in connection with any of the antitrust cases listed in response to Item No. 241." To add to this confusion, the Company responded to 13th Interrogatory Number 331 by stating that BSC-HQ employs 6 attorneys who work on "MFJ/antitrust" matters, for which test period Florida intrastate allocated charges totaled $282,900.

I believe that Southern Bell antitrust costs should be disallowed, in the smaller amount I derived from other discovery responses, unless and until the Company demonstrates benefits to ratepayers from its antitrust activities and provides an accurate accounting for such costs.

Q. Do you recommend similar treatment for the parent Company's MFJ legal charges to Southern Bell?

A. Yes. MFJ waivers sought by the parent are likely to be associated with non-regulated operations because the MFJ explicitly authorized regulated exchange and exchange access telephone services to be provided by Southern Bell. Similarly, MFJ compliance matters would relate primarily to Bellsouth's non-regulated business conduct.

Q. To what extent is Southern Bell dependent upon BSC-HQ for legal services?

A. According to the response to 11th Interrogatory, Number 284, BellSouth Telecommunications (Southern Bell and South Central Bell-post merger) has 78 lawyers throughout its operations, including 35 lawyers within the state organizations, 10 labor lawyers, 26 regulatory, marketing and network lawyers, 2 general corporate lawyers, 2 general support services lawyers, 2 legal vice presidents and 1 lawyer to support headquarters anti-trust and litigation matters. No adjustment is proposed for any of these telephone subsidiary lawyers.

BSC-HQ has 29 attorneys responsible for Federal regulatory, antitrust/MFJ, labor relations, tax, intellectual property, securities/corporate and litigation. My proposed adjustments addresses six or fewer of these headquarters lawyers.

Q. With respect to BSC-HQ corporate advertising, how did Southern Bell analyze the parent's advertising in deriving its proposed disallowance adjustment?

A. The Company appears to have evaluated the parent's advertising copy to determine the percent of each ad that was thought to be "product related" and therefore allowable. FCC Part 32 distinguishes between "product" and "corporate image" advertising, as follows:

> Account 6613 <u>Product Advertising</u>;
>
> This account shall include costs incurred in developing and implementing promotional strategies to stimulate the purchase of products and services. This excludes non product-related advertising, such as corporate image, stock and bond issue and employment advertisements, which shall be included in the appropriate functional accounts.
>
> (47 CFR, Ch. 1, 32.6613)

The Company's adjustment then disallows all BSC-HQ advertising except those individual ads determined to be "Product Related".

Q. Do you agree with this criteria for disallowance?

A. I agree that only product specific telecommunications advertising which is cost effective should be eligible for ratepayer recovery. Unfortunately, the Company appears to have not rigorously applied its own criteria. The BSC-HQ advertising costs Southern Bell did not disallow, which it proposes to recover from ratepayers, includes the cost of 50 percent of four print ads and 11/16 of several television ads which I believe are entirely corporate image-building advertisements.

Q. Did Southern Bell judge any of the BSC-HQ advertisements to be entirely product related and, thus, recoverable from ratepayers?

A. No. The only BSC-HQ advertisements not completely disallowed, were partially disallowed, at either a 50 percent or 5/16 (TV ads) level by Southern bell.

Q. Have you prepared an attachment to your testimony to illustrate the specific BSC-HQ advertising you propose be disallowed in its entirety, rather than only partially disallowed as proposed by Southern Bell?

A. Yes. Attachment MLB-5 contains advertising copy for the specific print and television ads disallowed by my adjustment (3rd POD, No. 49). Each of these ads was partially disallowed by Southern Bell, as described above. It is my opinion that these ads are entirely corporate image building rather than product-related advertisements.

Q. What activities are included within the BSC-HQ Corporate Affairs Department which you propose be disallowed?

A. Corporate Affairs is made up of four principal activity areas; Education Affairs, Executive Services, External Affairs and BellSouth foundation. Within Education Affairs, internal corporate resources are devoted to programs aimed at the improvement of public education in the southeast states. Executive Services includes planning and conducting executive/shareholder meetings, coordinating the Bellsouth Classic golf tournament and other customer positioning activities. External Affairs supports the BSC Chairman's external activities such as US Chamber of Commerce, JFK Center for the Performing Arts and United Way involvement as well as coordinating corporate contributions, corporate memberships and community affairs programs. BellSouth Foundation administration, involving the evaluation/approval of Foundation grants, is also included in the Corporate Affairs Department. (3rd POD, Item No. 41)

Q. Has the Company disallowed some of the allocated costs from BSC-HQ in its own adjustment?

A. Yes. Southern Bell's MFR Schedule A-6b, at page 23, disallows the allocated direct costs of BSC-HQ corporate contributions, Social/Service club memberships and dues and the BellSouth Golf classic. These adjustments total $352,000, the majority of which originate in the BSC-HQ Corporate Affairs Department.

Q. Why do you propose to disallow the remaining BSC-HQ Corporate Affairs costs, after reflecting Southern Bell's own disallowance adjustment?

A. It is my belief that Florida ratepayers receive no direct tangible benefits from the Corporate Affairs activities described above. The social and civic activities of the parent Company's executive management may enhance the public image of BellSouth, but such image enhancement should not be charged to ratepayers.

Q. What are the principal written work products of the BSC-HQ corporate affairs department and how are such work products said to be used to benefit Florida ratepayers?

A. According to the Company's response to the 11th Interrogatory, Item No. 286:

"The principal written work products of the BSC-HQ corporate affairs department are published reports of the BellSouth Foundation and BellSouth Education Affairs, including guidelines for requesting grants, annual reports, and special reports. These products benefit Florida ratepayers by advising them about how to seek financial support for education programs and providing other information related to improving education in the southeast, including Florida."
Also, the department provides written responses to external groups seeking support from the corporation or foundation, totaling approximately 1,500 annually. This correspondence supports Florida ratepayers by improving the corporation's awareness of and responsiveness to the interests of the community, including Florida.

Q. Does BSC-HQ also maintain a Washington D.C. Public Relations organization?

A. Yes. Responsibility Code H91000 is the BellSouth DC

Public Relations cost center responsible for Media Relations (11 INT, No. 275). This Media Relations function controls disclosure of centralized financial data and information regarding legislative/regulatory activities and corporate policy. National and international media relations support for BellSouth and its subsidiaries is provided, while corporate media opportunities are "created" with the national press for BellSouth officers in Atlanta and Washington. In the test period, the Florida Intrastate jurisdiction was charged $233,300 for these services.

Q. Why do you propose to disallow the BellSouth Public (Media) Relations costs?

A. I believe these activities and costs are similar in nature to the Corporate Affairs functions described above. Media Relations is an important concern to BellSouth as it endeavors to effectively create and utilize public media opportunities to enhance the image and advance the legislative/regulatory agenda of BellSouth. There has been no showing that regulated ratepayers in Florida need such media relations services in Washington or Atlanta or that they receive any tangible benefits from same.

Q. Have you also adjusted the BellSouth D.C. Federal legislative and regulatory relations charges through BSC-HQ to Florida?

A. No. I have accepted the Company's proposed disallowance of $812,000 within MFR Schedule A-6b, page 23 as a reasonable apportionment of such cost between ratepayers and shareholders. The Company's adjustment disallows two-thirds of such charges to Florida Intrastate, leaving a recoverable amount to recognize Southern Bell's dependence upon BSC-HQ for interaction with FCC personnel, with Federal-State Joint Boards, and with NARUC and other National entities/agencies.

Q. Does your Public Relations adjustment also disallow the expenses of the BSC-HQ Vice President-Public Relations?

A. Yes. The Public/Media Relations, Advertising and Corporate Affairs functions disallowed by my adjustments, above, report to the Vice President-Public Relations. I have, therefore, also disallowed the responsibility code charges to Florida Intrastate for this Vice President.

Q. What is the total amount and percentage of BSC-HQ costs charged to Southern Bell-Florida Intrastate operations which you propose to exclude as a proprietary disallowance?

A. Test period BSC-HQ charges to Florida-Intrastate that I propose be disallowed can be summarized as follows:

BSC-HQ Department-Function	1991 total BSC-HQ$	Florida Intrastate Charged	Proposed Disallowed Proprietary
Legal-Antitrust/MFJ	$10,372,321	$1,432,900	$ 117,422
Advertising	7,072,581	831,900	831,900 A
Corporate Affairs	6,208,450	844,600	844,600 A
BellSouth DC-Public Relations	1,419,315	233,300	233,300
VP-Public Relations	462,831	70,206	70,206
Total Amounts	25,535,498	3,412,906	2,097,428
Less: Amount Excluded by Southern Bell's Adjustment			(853,000)
Total Public Counsel Proposed Disallowance			$1,244,428

A - Includes amounts also disallowed by Southern Bell.

This total Public Counsel proposed proprietary disallowance amount ties to Exhibit ____(MLB-1) at line 25 and should be added to the Company's own proprietary exclusion of $1,665,000 of BSC-HQ costs.

RESEARCH AND DEVELOPMENT (R&D)

Q. What is the purpose of this section of your testimony?

A. This testimony section addresses Southern Bell's test period research and development expenses, explaining the nature of such activities and recommending certain adjustments to such expenses.

Q. Does Southern Bell purchase research and development services from affiliated companies for which costs are included in test year expenses?

A. Yes. The primary affiliate providing R&D services to Southern Bell is Bell Communications Research, Inc. (BELLCORE). BELLCORE was established at divestiture as a centralized national R&D and centralized service organization, owned equally by each of the seven Bell Regional Holding Companies (RHC's), to provide applied research, national security and emergency preparedness, operational support and common administrative systems support on a shared-cost basis. BELLCORE offers a broad spectrum of technical and operations R&D and support services through a series of programs and detailed projects. A "project" tracking and cost accounting system is employed by BELLCORE to accumulate and charge its incurred costs in each detailed project among the

RHC's. BELLCORE is a valuable resource to Southern Bell and other Bell operating companies because it is uniquely positioned to serve the mutual interests of its owners and clients on a national basis, sharing the costs of supporting common automated systems, centralized National Security/Emergency Preparedness (NSEP) and telecommunications R&D. However, the nature of the services provided by BELLCORE in the R&D domain raises significant regulatory policy issues.

A second, much smaller source of R&D services to Southern Bell is the Science and Technology (S&T) organization within BellSouth Services. S&T conducts more focused technology development work in selected areas of interest to BellSouth. S&T is building BellSouth's Advanced Intelligent Network (AIN) laboratory and a related service creation environment for the production of new advanced services to be provisioned through Southern Bell's AIN networks of the future.

Q. What total amount of test year expense was incurred by Southern Bell in Florida for R&D services from these two sources?

A. Florida Intrastate BELLCORE expenses totaled $29,089,484 in 1991 (11th Interrogatory, Item No. 269). BellSouth

Services S&T expense to Florida Intrastate were $797,575 (13th Interrogatory, Item No. 333).

Q. What are the BELLCORE program areas which are used to group the numerous specific projects funded by Southern Bell?

A. BELLCORE activity is grouped by work program, with each program containing a number of similar projects. The 1991 BELLCORE work programs were as follows:

- APPLIED RESEARCH
- GENERIC REQUIREMENTS
- NETWORK STANDARDS & ARCHITECTURE
- NETWORK SERVICES
- PLANNING & ENGINEERING
- OPERATIONS & PROVISIONING
- PROCUREMENT SUPPORT
- TECHNICAL ANALYSIS
- TECHNICAL TRAINING
- COMPUTING STANDARDS & ARCHITECTURE
- SUPPORT SERVICES
- MARKETING SERVICES
- FEDERAL REGULATORY
- REGULATORY SUPPORT
- ACCOUNTING & FINANCIAL STANDARDS
- BILLING SYSTEMS
- COST SYSTEMS
- PRICING
- DIRECTORY SERVICES SUPPORT
- PUBLIC RELATIONS
- CORPORATE MEASUREMENTS
- GOVERNMENTAL AFFAIRS
- PLANNING RESEARCH

Q. Do other Bell telephone companies across the country incur R&D costs comparable to Southern Bell's expenditures for R&D?

A. All of the Bell RHC's participate at varying levels in BELLCORE projects. Some of the Bell RHC's also have some internal technology development and deployment capabilities, however the level of commitment to proprietary in-house R&D varies among the RHC's.

Q. What ratemaking issues are raised by the existence of substantial R&D activities and costs incurred by Southern Bell?

A. <u>The fundamental issue with respect to R&D expenditures of regulated telephone companies is whether current ratepayers should bear the costs of such R&D, given the degree to which they benefit from such expenditures.</u> Related sub-issues include the following:

a) The benefits of successful R&D will be realized in the future, suggested that R&D costs should be deferred and matched to the period of benefits. (Subsidization of future Southern Bell customers.)

b) The benefits of successful Southern Bell-funded R&D may be realized by non-regulated affiliates of the telephone company. (Subsidization of Southern Bell affiliates.)

c) The benefits of successful Southern Bell-funded R&D may be realized by Southern Bell, but in future products or services treated as non-regulated by the Florida Commission. (Subsidization of Southern Bell Non-Regulated Services.)

d) Southern Bell regulated operations may serve as a funding vehicle for speculative R&D aimed at new technologies of potential interest to BellSouth's diversified businesses, which would be too risky to absorb as a start-up cost of a new BellSouth business venture on a stand-alone basis. (Subsidization of BellSouth new business risks.)

e) Southern Bell funded R&D may be unsuccessful, resulting in no benefits to ratepayers.

Q. Have you examined the research and development expenditures of Southern Bell, mindful of these concerns and potential issues?

A. Yes. I have reviewed the voluminous BELLCORE project profiles and a number of other documents associated with Southern Bell's BELLCORE expenditures. These documents include BELLCORE's Business Plan, various NARUC and NARUC-FCC Audit Reports on BELLCORE, BellSouth Services cost/benefit studies, as well as example work products and explanations of R&D activities of both BELLCORE and the BSS S&T entities. The documents I have reviewed, as described in the following testimony, support an adjustment which allows current rate recovery of most of Southern Bell's R&D expenditures, but recommends disallowance with possible future recovery of certain R&D costs.

Q. Has BELLCORE been audited by other regulatory agencies in the recent past?

A. Yes. Aside from periodic rate case reviews by state PUC's of BELLCORE expenditures to determine rate-recoverability, the NARUC Subcommittee on Accounts has received audit reports regarding BELLCORE from a multi-state joint audit team in 1985, 1988 and in October 1991 (joint NARUC-FCC Phase I Report). The most recent

October 1991 <u>Report on the Review of BELLCORE Financial Activities</u>, issued by the NARUC-FCC Accounting Task Force Audit Team, addresses only overall financial issues, rather than the broader technology policy issues addressed in earlier NARUC audits. However, I understand that a Phase II Report may be issued by year-end and will again address the technical work effort of BELLCORE.

Q. How did the most recent NARUC <u>technical</u> (rather than financial) review of BELLCORE categorize project work efforts?

A. After reviewing the 692 BELLCORE projects which existed in 1987, the NARUC project review group categorized the BELLCORE projects into four broad areas in its 1988 Report:

A - Applied Research: Projects reviewed in this area related to activities performed to determine the technical feasibility of incorporating new technology into the network.

B - Existing Technology: Projects reviewed here deal with Bellcore activities relating primarily to today's software systems and is in large part maintenance oriented. Reviewed here are such familiar systems as TIRKS, FACS AND PICS/DCPR.

C - Emerging Technology: These projects relate to development activities to incorporate new technology or software into Regional Networks. Prominent in this area is work *involving* ISDN *and* IN/2.

D - Financial Projects: These projects do not relate directly to operating the telecommunications network and may be thought to be more of a support or ancillary nature.

According to the 1988 NARUC project review group, "The four groupings were utilized since they pose different types of concerns for regulators". (3rd POD, Item No. 689, NARUC 1988 Audit, p. 174)

Q. How did the NARUC BELLCORE auditors describe the ratemaking concerns with these categories of projects in the 1988 audit report?

A. The primary concern throughout NARUC's 1988 BELLCORE project review section of the audit report was the linkage between project activities and benefits to current ratepayers of regulated telephone company services. *For each of the project categories used by the*

NARUC auditors, the regulatory questions or issues were summarized as follows:

- <u>Research</u> with no direct relationship to customer or service requires a high level policy decision to be made by State Commissions.

- The <u>Existing Technology</u> projects bear the closest relationship to today's customer, are maintenance oriented and are performed at Bellcore because of economies of scale (scope also comes into place). Concerns with existing technology relate to the efficiency of the maintenance activities and perhaps creeping featurism, discussed in part 4 of this report.

- The <u>Emerging Technology</u> projects, which are well along in the development scale, are being performed for specific service or benefit discrete customers groups. Rate Design and Capitalization issues appear prominent here. Economies of Scope and Limited Expertise are driving factors here with Economy of Scale also coming into plans.

- The <u>Financial Projects</u> which are not as directly tied to network technology as other projects can be more readily offered by third parties; and questions arise as to the wisdom of having Bellcore perform these functions.

With these concerns in mind, the NARUC auditors stated as their purpose, "In order to determine if any or all of Bellcore's project costs should be borne by monopoly customers, we must understand both what Bellcore does and how the regions use it." (NARUC 1988 Audit, p. 175)

Q. What adjustments or other recommendations did the NARUC auditors recommend in 1988 for each of the four Bellcore project categories?

A. There was some diversity of recommendations among the distinct audit groups involved in the NARUC audit in 1988. For example, with respect to the Applied Research category, the Accounting Review group considered capitalizing research costs to better match such costs to future periods when related benefits would be realized. The Project Review group, out of concern that applied research may benefit future deregulated services after being funded by monopoly ratepayers, recommended alternative methods to allocate research costs between regulated and nonregulated accounts. The Regional Group recommended that only 20 percent of applied research costs are used and useful to current ratepayers and the other 80 percent should be disallowed. The allowable 20 percent would then be deferred and amortized over 7 years to better match costs with benefits. (NARUC 1988 Audit Report at pages 30-32).

With respect to the Existing Technology category, more of a consensus among the NARUC audit groups existed. Projects in this category, "deal with maintaining and enhancing today's network system and are the most innocuous of the four sections reviewed" (NARUC 1988 Audit Report at p. 33)

The Emerging Technology category was found to deal with the transition to tomorrow's network, and in some ways form a bridge between knowledge gained in Applied Research and actual implementation by the operating companies. The Audit concluded that, with respect to Emerging Technology, in many cases there is no benefit to current residential ratepayers and that the possibility of such Bellcore work benefiting future deregulated services justifies careful study of proper cost assignment methods.

Financial Projects were found to be less directly related to provisioning or maintaining telephone service, but were administrative and general support functions that seemed justified by cost savings associated with shared economies of scale. (NARUC Audit Report, page 34)

Q. To what extent did you rely upon the NARUC audit of Bellcore that was conducted in 1987 and reported in 1988?

A. I used this NARUC Audit Report and prior NARUC reviews of BELLCORE as background information in reviewing the activities and benefits of Bellcore as they relate to Southern Bell in Florida. The 1988 NARUC Audit Report was not designed to resolve rate case issues, as stated at page 20 of the Executive Summary:

> The approach taken in this report is to provide information that state regulators can use to make decisions - not to necessarily resolve issues. The difference, which may be subtle, is significant. Consensus in multi-state audits requires compromise among differing state opinions, which is

antithetical to a basic NARUC tenet---state's right to deal individually with state matters. This report has been fashioned to give state regulators the information needed to resolve matters in accordance with its own agenda.

My review of BELLCORE as stated herein, relied upon specific interrogatories and document requests aimed at evaluating the extent to which the costs of BELLCORE activities in the test period are properly recovered from today's regulated ratepayers.

Q. Before explaining your approach to Southern Bell's R&D payments to BELLCORE and BellSouth Services S&T organization, what is the status of the more recent 1991-1992 NARUC investigation of BELLCORE?

A. A joint NARUC-FCC audit report was recently completed and a Phase I report was issued October 30, 1991 to address "Financial Activities" of BELLCORE. The findings in the Phase I report do not address the nature of work conducted by BELLCORE, but instead focus on internal accounting, costing and pricing issues. These concerns are resolved by adjustments already made by Southern Bell or BELLCORE and are not addressed further in my testimony.

A Phase II report may be issued by year-end by the NARUC-FCC Accounting Task Force Audit Team which will once again address the technical work efforts of Bellcore. This "next" audit report is aligned with the issues addressed in my testimony and may be of significant interest to the Commission as a more contemporary overview of Bellcore by NARUC and the FCC.

Q. What specific documents did you rely upon to understand the activities of Bellcore?

A. The principal documents I relied upon are the Final Project Offering documents contained within the 1991 Customized Work Program purchased by Southern Bell from BELLCORE in the test period. This documentation consists of five volumes of detailed profiles of each BELLCORE project. The BELLCORE "project" is the unit of activity used to accumulate costs incurred for a defined scope of work having specified deliverables, clients, budgeted resources and billing authority.

Southern Bell provided the actual test period Florida intrastate Bellcore expense for each project in its response to 11th Interrogatory, Item No. 269. Other documents I reviewed include the BELLCORE Service Agreement with the RBOC'S (13th POD, Item No. 164), a series of specific interrogatories (2nd Interrogatory), the BELLCORE 1991 1991 Annual Report to Shareholders and Accounting Instructions (3rd POD, Item No. 65) and BellSouth Service's "cost/benefit analyses" of individual BELLCORE projects. (3rd POD, Item No. 62)

Q. Does your R&D adjustment also include the BellSouth Services Science & Technology (S&T) activities previously referenced?

A. Yes. Beyond its BELLCORE funding, Southern Bell also pays BellSouth Services for S&T activities related to its Advanced Intelligent Network (AIN) laboratory, Switched Multimegabit Data Service and Broadband Integrated Services Digital Network (SMDS/BISDN) research and other activities.

Q. Have you prepared a schedule listing the specific BELLCORE and S&T projects you propose to exclude from Southern Bell's operating expenses?

A. Yes. Exhibit (MLB-2) lists the BELLCORE and BellSouth Services S&T projects and test period intrastate expenses for such projects that I propose to be removed from test period expenses. The basis for the exclusion of these projects is that they do not result in benefits to ratepayers of Southern Bell's currently offered regulated services. Additionally, these projects create significant risk to ratepayers because of the "sub-issues" listed at page 51 which justify disallowance, with possible future recovery of these project costs.

These listed projects represent a modest portion of Southern Bell's overall BELLCORE and S&T test period expenses which, arguably, should be disallowed or, in the alternative, deferred to future periods and matched with demonstrated above-the-line ratepayer benefits when such matching is possible.

Q. What are the BELLCORE projects you would disallow or defer for future recovery consideration?

A. Lines 2 through 30 of Exhibit ___ (MLB-2) set forth the specific BELLCORE projects I propose to exclude from Southern Bell's Florida Intrastate revenue requirements. To document and support each project, I have attached as Appendix MLB-6 the related Project Descriptions from Southern Bell's response to 3rd POD, Item No. 70. On each project description I have indicated, by vertical bar in the right margin, the language I rely upon to support a conclusion that near term benefits to Florida regulated ratepayers are not evident. There are a total of 702 individual projects funded by Southern Bell and documented for the 1991 test period, but the Appendix includes copies of only the 28 projects I would exclude.

Q. What specific recommendation do you offer with respect to these Bellcore projects and the S&T activity costs?

A. The costs of these projects, which represent the more forward-looking advanced network technology endeavors, should <u>not</u> be included in current revenue requirements. I recommend that the costs related to these 28 projects be disallowed at this time. However, Southern Bell should be authorized to maintain separate "side records" of the disallowed costs from these projects (and equivalent successor projects) so that, in future rate proceedings, rate recovery of such costs (including reasonable interest thereon) may be reconsidered if telephone ratepayer above-the-line benefits are demonstrated.

Q. How did you determine the projects you would disallow are the more futuristic "network of the future" activities at Bellcore?

A. I relied primarily upon the project profiles which describe each project in terms of its research direction, deliverables, past accomplishments and a common language overview. Additionally, the Company's cost/benefit studies for these projects indicate their future network orientation.

As an example of the future benefit nature of this BELLCORE work, I note that disallowed projects numbered 021411, 421301, 421303, 621204, 621405, 621406, 621409 and IR3011 relate to development of a "next generation" communications network based upon fiber optic broadband transport of voice, data and video information. When and if such a ubiquitous high-speed broadband fiber network is deployed to provide regulated telephone service, the costs of these projects may be determined to be recoverable by the FPSC. However, it is possible that the future services this technology may enable Southern Bell to deploy, such as packet video, multimedia teleconferencing, multimedia messaging and video on demand will be determined to be competitive (non-monopoly) services that would not yield regulated, above-the-line revenues.

Similarly, when and if Southern Bell deploys information networking services through new technology platforms such as ISDN, Broadband ISDN and Advanced Intelligent Networks (AIN) as regulated, above-the-line services in Florida, it may be reasonable to allow ratepayer recovery of BELLCORE project 1R1311, 1R3111, 1R4127, 1R4211, 1R501N, 1R502X and 621307. The technologies to deliver information networks, video and multimedia services include synchronous optical networks (SONET) and SMDS, which are under development in projects 1R3521, 1R411, 1W0111, 1W0211, and 1R212. If the Southern Bell's regulated network is ultimately used to distribute high definition television (HDTV) to the public in Florida, BELLCORE project 421306 should be recoverable from ratepayers. Speech and Image Processing (project 621408) promises exciting potential future services using synthesized voice recognition and network interaction as well as video compression to enable video service applications prior to full fiber deployment. As a final example, BELLCORE project 1R4111 and the Service Company's S&T AIN laboratory provide for work on "Advanced Intelligent Network" (AIN) applications to plan for evolution toward telephone company intelligent networks through the 1990's. Such intelligent network capabilities, when deployed in Florida, will allow rapid service creation and modification via software controlled by Southern Bell, improved network trouble isolation and other ratepayer benefits. However, if new AIN provisioned services are eventually offered on a deregulated basis, shareholders should bear the BELLCORE and S&T development costs.

Q. How does Southern Bell describe the status of its plans for deployment of broadband ISDN technology within the Florida network?

A. According to the Company's response to 15th Interrogatory, Item No. 371, the status of broadband ISDN deployment is uncertain, which in my opinion does not support the current above-the-line expensing of R&D for this technology, as proposed by Southern Bell. The Company's response states:

> "Current Southern Bell plans regarding broadband ISDN are to install technology trials as appropriate to verify standards and test equipment. No volume deployments are in Southern Bell's near term plans. The regulatory status of any service to be derived from broadband ISDN is unknown at this time. Benefits to be derived from broadband ISDN cannot be quantified until the results of the technology trials are known and analyzed.

Q. Is the status of deployment of Advanced Intelligent Network (AIN), video/advanced television, PCS/wireless and Synchronous Optical Network (SONET) technology similarly uncertain?

A. Yes. (See 15th Interrogatories Number 372 through 375).

Q. Does BELLCORE also provide more fundamental research into emerging technologies of potential future application by the BellSouth companies?

A. Yes. Projects 821101, 821102 and 821103 address optical and electronic devices in terms of basic materials research, physics, and fabrication methods. BELLCORE and BellSouth are prohibited by MFJ restrictions from designing and manufacturing telecommunications devices, but hope to influence the vendor community and expand fundamental knowledge about such devices to participate in evolving the technologies available to telecommunications.

Q. Does BELLCORE continue to support BellSouth efforts to deploy enhanced network capabilities in the local loop?

A. Yes. Projects 621306 and IW1511 address technical concerns surrounding fiber in the loop issues. Project 421302 involves applied research into digital radio capabilities to provide radio local area data networks and other "highly flexible tetherless digital data and voice services that cannot be offered now."

Q. Are most of the BELLCORE project dollars you propose to disallow within the "Applied Research" program?

A. Yes. The projects listed at lines 2 through 16 of Exhibit ___ (MLB-2) represent Applied Research. The remaining projects would probably have been categorized as "Emerging Technology" in the NARUC audit categorization previously discussed herein.

Q. How does BELLCORE describe the goals and objectives of its Applied Research programs?

A. According to the <u>Bellcore Business Plan Analysis for 1990-1994</u> (3rd POD, Item No. 66), the Goals/Objective for Applied Research are:

> Applied Research's technological strategy stems from a long-term vision of the technological future of telecommunications. Today's public narrow-band networks are already proving inadequate to meet the growing high-speed needs of the large data users, especially big businesses. This will be accelerated by the potential business and residential use of image and video, especially

> in the entertainment and education markets. It is essential to encourage and guide the rapid evolution of the public networks into truly broadband, intelligent, friendly networks supporting information networking. These broadband intelligent networks must be able to support, at will, information networking services involving any or all of the complete gamut of communications media -- voice, data, facsimile, image, and video.

These Applied Research Goals/Objectives then carry over into the network areas of BELLCORE activity where the short-term goal, according to the same source, is to:

> Become a strategic partner with each of the Client Companies in defining and implementing financially viable, incremental steps toward the Information Networking Vision, while maintaining a profitable network business.

These statements, in my opinion, clearly indicate that current period BELLCORE R&D in the project areas I propose to adjust, are aimed at a boldly redefined future communications network incorporating many new products and services bearing little resemblance to basic telephone services provided today.

Q. Has Southern Bell studied the cost/benefit justification for the work done by BELLCORE?

A. In response to 3rd POD, Item No. 62, the Company produced a voluminous document labeled as "Cost/Benefit Analysis" for the 1992 BELLCORE Projects. However, these "analyses" did not quantify any benefits from BELLCORE efforts. Indeed, the Company has repeatedly admitted that it cannot estimate such future benefits because network applications of new technologies remain uncertain. Instead, the Company's cost/benefit studies merely assume that BellSouth would necessarily replicate the BELLCORE project activities without the benefits of cost sharing with the other six RBOC's. It is not surprising that such "analysis" indicate that independent BellSouth conduct of its own R&D to replace shared-cost BELLCORE activities is not cost-effective.

Q. Does your testimony challenge the cost effectiveness or efficiency of BELLCORE?

A. No. Instead, I challenge the <u>nature</u> of the R&D services provided by BELLCORE and the implicit assumption that today's regulated ratepayers are the beneficiaries of virtually all BELLCORE project activities, as suggested by the Company's accounting for such costs. The replacement cost to create internally, rather than buy, R&D services not needed to provide 1993-vintage telephone services is largely irrelevant, in my opinion.

Q. Turning to BellSouth Services Science and Technology (S&T), the affiliate responsible for BellSouth proprietary research, do the same types of issues apply?

A. Yes. According to Southern Bell's response to 15th POD, Item 222, S&T provides R&D services to Southern Bell that are described as:

> "Includes building the Advanced Intelligent Network (AIN) lab and a service creation software development environment and then development of advanced services software for deployment in the BOC networks using the Advanced Services Platform for the Intelligent Network (ASPIN). Functions include: planning, programming and testing of services software."

> "Deliverables will include advanced services for BOC networks in more timely and custom

design manner than previously possible. These will exploit the evolving Advanced Intelligent Network (AIN) capabilities to increase revenue and decrease expenses."

Another principal technology area being investigated by S&T is Broadband ISDN for use in Local Area Network (LAN) interconnection and host-to-host communications with Switched Multimegabit Data Service (SMDS). Other S&T areas of inquiry include Fiber to the Curb (FTTC), SS7 performance standards, network disclosure references and network equipment evaluations. These three S&T categories, AIN, SMDS/BISDN and appear on lines 32 through 34 of Exhibit __ (MLB-2).

Q. What is the basis for your proposed disallowance of the AIN and SMDS/BISDN costs allocated from S&T to Southern Bell?

A. My evaluation of the S&T projects at BellSouth Services caused me to conclude that S&T work is primarily oriented toward future enhanced (and potentially non-regulated) services which clearly do not benefit current regulated SWBT products and services.

Q. Has Southern Bell deployed any AIN or SMDS/BISDN services in Florida?

A. No.

Q. Near the beginning of the R&D section of your testimony, you identified the matching issue that arises from the fact that R&D expenditures yield benefits over future time periods. Does Southern Bell acknowledge the <u>future</u> benefit from its R&D expenditures?

A. Yes. In response to 9th Interrogatory, Item No. 246, Southern Bell described the ratepayer benefits of the S&T organization relative to BELLCORE to be:

> Bellcore is an excellent vehicle for doing R&D in areas of mutual interest. However, the interests of the various regions are diverging because of the different geographical, political, regulatory, and economic characteristics of the regions that they serve. These differences cause the regional operating companies to make different choices in many fundamental technical areas such as SS7, digital switching deployment, AIN, etc., particularly in the timing of deployment of these capabilities. Internal R&D is necessary

> to support the transfer of Bellcore and vendor technology to BellSouth and to allow for customization to meet specific BellSouth needs.
>
> Research & development identifies, defines, and develops new technologies and services that can control costs and/or provide new capabilities that are necessary to move the public network <u>into the future.</u> Ratepayers benefit because they can expect to enjoy an improved standard of living over time <u>if the communications infrastructure in the region in which they live continue to improve and is capable of supporting even more sophisticated services</u>. Many of the new services being envisioned, e.g., Call Name Delivery, improve both the personal and economic security of the citizens. (Emphasis added)

Q. What accounts are used by Southern Bell to record the BELLCORE and S&T expenditures you would disallow?

A. Most of the BELLCORE and S&T projects I would disallow are charged to Southern Bell's Account 6727 <u>Research and</u>

Development. FCC Part 32 rules define this account as follows:

> **§ 32.6727 Research and development.**
> (a) This account shall include costs incurred in making planned search or critical investigation aimed at discovery of new knowledge. It also includes translating research findings into a plan or design for a new product or process or for a significant improvement to an existing product or process, whether intended for sale or use.
> (b) This excludes making routine alterations to existing products, processes, and other ongoing operations even though those alterations may represent improvements.
>
> (47 CFR, Ch. 1, § 32.6727)

By charging the costs of these specific projects to the R&D account, Southern Bell implicitly admits that these costs do not relate, "to existing products, processes, and other ongoing operations...", but are instead aimed at, "...a new product or process or a significant improvement" which will create future benefits.

Q. Is it possible for BellSouth to be made whole for the R&D costs disallowed in Southern Bell rate cases by deploying new technologies in non-regulated markets?

A. Yes. Nothing acts to preclude Southern Bell or any non-regulated subsidiary from employing technologies developed by BELLCORE or S&T outside of regulation. For this reason, the R&D adjustment I propose should be viewed as not punitive to the Company. The Company can either deploy technological innovations in its future regulated operations and seek rate recovery of previously disallowed R&D costs, <u>or</u> it can elect to deploy new technology in Southern Bell or another affiliate on a non-regulated basis.

Q. Have you reviewed the Commission's Order No. 25218 in Docket No. 890190-TL, in re: Petition of CITIZENS OF THE STATE OF FLORIDA to investigate SOUTHERN BELL TELEPHONE AND TELEGRAPH COMPANY'S Cost Allocation Procedures?

A. Yes. At page 19 of its Order, the Commission concludes its discussion of BELLCORE expenses by stating, "...Southern Bell will be filing MMFR's no later than March 31, 1992. It would be appropriate to review the R&D expense in those proceedings to determine if there are charges which should be capitalized for regulatory purposes that have not come to our attention in this docket."

Q. Is it your testimony that the BELLCORE and S&T projects within your proposed adjustment should be capitalized for regulatory purposes?

A. I recommend these costs be deferred for <u>possible</u> future consideration as an above-the-line regulated expense, subject to a reasonable demonstration of ratepayer benefit from the technologies being researched. This recommendation is somewhat different from more traditional capitalization of a regulatory asset, as governed by Financial Accounting Standard No. 71 <u>Accounting for the Effects of Certain Types of Regulation</u>, which is dependent upon evidence that future rate recovery of the amount capitalized by "<u>probable</u>". It is simply too early to tell if and when regulated ratepayers will benefit from new technologies that may ultimately be part of the network of the future.

Q. Do Generally Accepted Accounting Principles (GAAP) preclude the disallowance or regulatory deferral of R&D costs?

A. No. GAAP governs the accounting treatment of R&D costs in the general business environment for public financial statement purposes and generally provides for expensing of R&D costs, in the interest of conservatism, within financial statements. However, GAAP does <u>not</u> govern the costing or pricing of regulated utility services and does not dictate how R&D costs should be apportioned among subsidiaries in relation to current or future benefits, within the context of utility rate proceedings.

Q. Does this conclude your testimony?

A. Yes.

SOUTHERN BELL TELEPHONE & TELEPGRAPH COMPANY
BELLSOUTH CORPORATE SERVICES CHARGES
TEST YEAR 12/31/91

EXHIBIT ___ (MLB-1)

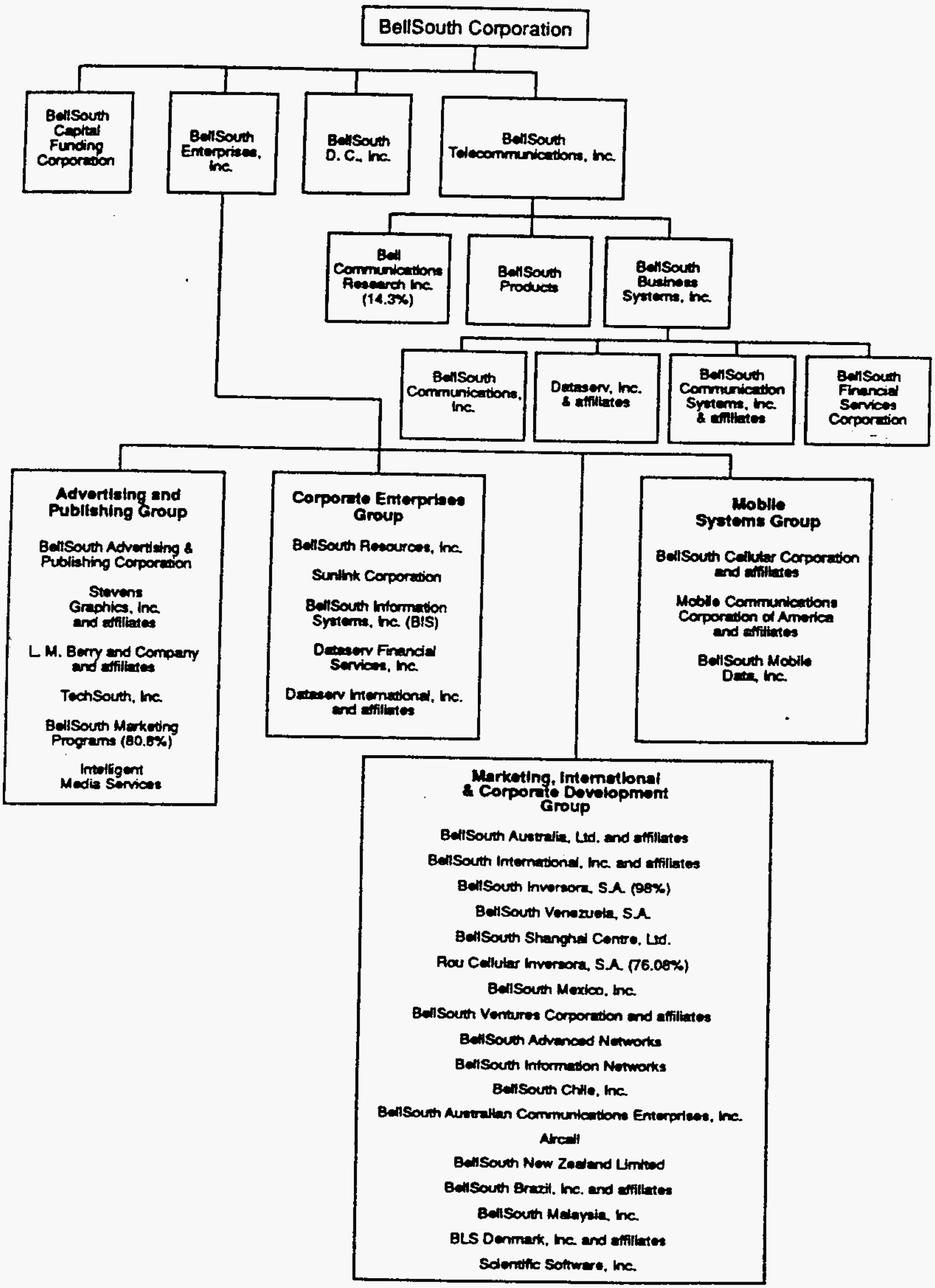
LINE NO	DEPARTMENTAL DESCRIPTION:	BILL CODE	FLORIDA ALLOCATED	FLORIDA INTRASTATE	DISALLOWED BY SBT	SBT ADJUSTED INTRASTATE	OWNERSHIP DISALLOWED BY OPC	PROPRIETARY DISALLOWED BY OPC	PUBLIC COUNSEL ADJUSTED INTRASTATE
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1	EXECUTIVE	EXEC	1,977,300	1,415,300	0	1,415,300	(429,012)	(70,206)	916,082
2	CORP. SECRETARY	H110	943,300	675,100	0	675,100	(82,859)	0	592,241
3	TREASURY	H112	3,029,500	2,107,700	0	2,107,700	(590,148)	0	1,517,552
4	SECURITY	H130	372,300	250,500	0	250,500	0	0	250,500
5	COMPTROLLERS	H131	1,688,800	1,174,900	0	1,174,900	0	0	1,174,900
6	TAX	H15X	1,312,500	913,200	0	913,200	0	0	913,200
7	INTERNAL AUDIT	H17X	444,100	309,000	0	309,000	0	0	309,000
8	FINANCIAL MANAGEMENT	H22X	702,200	488,600	0	488,600	0	0	488,600
9	CORPORATE PLANNING	H23X	1,235,500	893,300	0	893,300	(446,650)	0	446,650
10	BS H/R INC -- OTHER	H5A2	821,800	547,400	0	547,400	0	0	547,400
11	BS H/R INC -- BENEFIT	H5A9	3,086,400	2,055,700	0	2,055,700	0	0	2,055,700
12	HUMAN RESOURCES	H5XX	4,690,400	3,124,100	0	3,124,100	0	0	3,124,100
13	ASST SEC/CORP COUNSEL	H616	88,800	55,500	0	55,500	(27,750)	0	27,750
14	LEGAL	H61X	2,291,600	1,432,900	0	1,432,900	0	(117,422)	1,315,478
15	FEDERAL RELATIONS	H71X	1,731,700	1,221,300	(812,000)	409,300	0	0	409,300
16	ADVERTISING	H902	1,179,500	831,900	(501,000)	330,900	0	(330,900)	0
17	PUBLIC RELATIONS	H910	330,800	233,300	0	233,300	0	(233,300)	0
18	EXTERNAL RELATIONS	H920	1,293,300	912,100	0	912,100	0	0	912,100
19	ASST SEC / CORP AFFAIRS	H940	1,180,000	844,600	(352,000)	492,600	0	(492,600)	0
20	FED PAC	H112/	30,500	0	0	0	0	0	0
21	TOTAL		28,430,300	19,486,400	(1,665,000)	17,821,400			15,000,552
22	SOUTHERN BELL BELLCORE ADJUSTMENT				(190,000)				
23	COMPANY MFR SCH A-6b PAGE 23 OF 36				(1,855,000)				
24	OPC PROPOSED OWNERSHIP DISALLOWANCE BSC-HQ EXPENSE						($1,576,419)		
25	OPC PROPOSED PROPRIETARY DISALLOWANCE BSC-HQ EXPENSE							($1,244,428)	

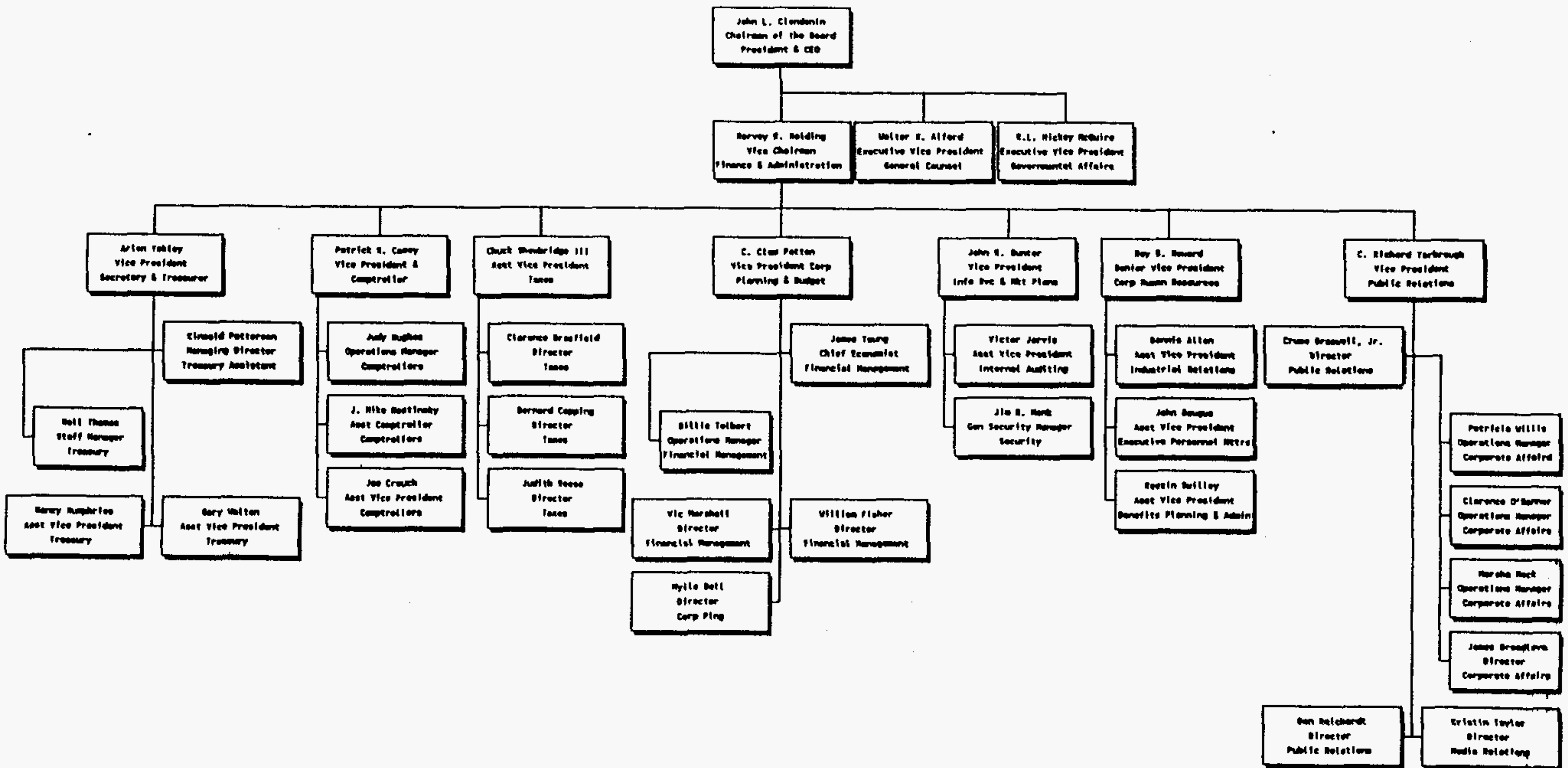
EXHIBIT____(MLB-2)

SOUTHERN BELL TELEPHONE AND TELEGRAPH COMPANY
FLORIDA DOCKET NO. 920260-TL
SUMMARY OF BELLCORE AND S&T PROJECTS DISALLOWED
TEST YEAR 1991

LINE NO.	DESCRIPTION	REFERENCE	PROJECT NO.	FLORIDA INTRASTATE
1	BELLCORE ADJUSTMENT ELEMENTS (PROJECTS):			
2	Systems Integration	3 POD #70	021411	$151,743
3	Lightwave Systems Technology	"	421301	177,855
4	Radio Research	"	421302	122,520
5	Transwitching Technology	"	421303	128,355
6	Video Systems Technology	"	421306	196,865
7	Systems Principles	"	621204	119,711
8	Distribution Network Technology	"	621306	164,399
9	Network Control	"	621307	129,274
10	Network Systems	"	621405	162,050
11	Multimedia Communications	"	621406	195,400
12	Speech and Image Processing	"	621408	130,828
13	Computer Networking	"	621409	167,876
14	Photonic Science and Technology	"	821101	333,389
15	Electronic Science and Technology	"	821102	296,659
16	Photonic and Electronic Materials	"	821103	232,338
17	Switched Fractional DS1 and Switched DS1	"	1R3521	48,997
18	AIN Release 1 Planning & Requirements	"	1R4111	336,595
19	SONET Release 1.0 Infrastructure	"	1W0111	80,457
20	SONET Release 2.0 Infrastructure	"	1W0211	93,268
21	FITL Requirements & Architecture Planning	"	1W1511	157,174
22	SMDS Phase 2 Planning & Requirements	"	1R2112	218,027
23	BISDN Phase 1 Planning & Requirements	"	1R3011	197,361
24	SCAI and Intelligent Network Standards	"	1R4127	40,983
25	Information Networking Architectures	"	1R501N	133,033
26	Integrated Operations Support of INA	"	1R502X	53,864
27	Information Networking ISDN Planning	"	1R1311	39,094
28	Information Networking BISDN Planning	"	1R3111	38,326
29	Information Networking AIN Planning	"	1R4211	36,276
30	TOTAL BELLCORE ADJUSTMENT AMOUNT			$4,182,717
31	BELLSOUTH SERVICES SCIENCE & TECHNOLOGY PROJECTS:			
32	Advanced Intelligent Network (AIN)	13 INT #333		$566,284
33	Switched Multimegabit Data Service/ Broadband ISDN	"		135,591
34	Other	"		95,700
35	TOTAL SCIENCE AND TECHNOLOGY ADJUSTMENT AMOUNT			$797,575
36	TOTAL PUBLIC COUNSEL RESEARCH AND DEVELOPMENT ADJUSTMENT (Lines 30 + 35)			($4,980,292)

BellSouth Corporate Structure





As of May 1, 1992

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Attachment MDB-2
Page 1 of 3

- John L. Clendenin, Chairman of the Board, President & CEO
  - Harvey R. Holding, Vice Chairman, Finance & Administration
  - Walter H. Alford, Executive Vice President, General Counsel
  - R.L. Mickey McGuire, Executive Vice President, Governmental Affairs
    - David Markey, Vice President, Federal Regulatory
      - William Jordan, Director, Federal Regulatory
      - Maury Talbot, Jr., Director, Federal Regulatory
      - Vacant, Director, Federal Regulatory
      - Francis Urbany, Directory, Int'l/Agency Relations
      - Robert Blau, Director, Regulatory Policy Analys.
      - Don Hathcock, Director, Staff Relations
      - Pepper English, Director, Staff Relations
    - Karen Possner, Director, Legislative Policy
    - Dan Mattoon, Director, Congressional Affairs
    - Dan Murray, Director, Congressional Affairs
    - David Williams, Director, Federal Relations
    - Scott Matthews, Director, Legislative Affairs

As of May 1, 1992

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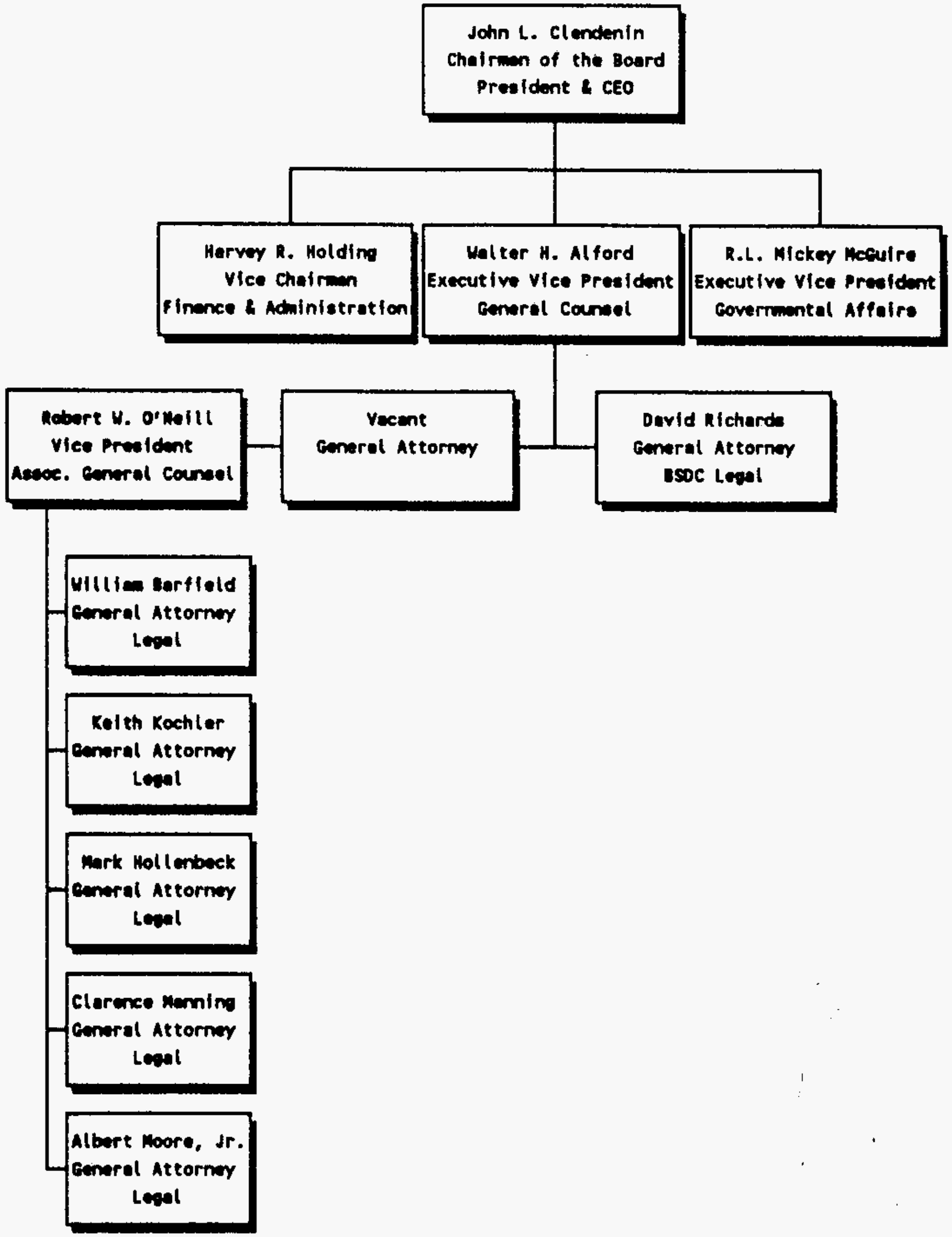
Attachment MLB-2
Page 2 of 3



As of May 1, 1992

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FC Co, Interrogatories Item # 34 Attachment A

BELLSOUTH CORPORATION
POSITION DESCRIPTION

Position Title: Chairman, President, and Chief Executive Officer

Code:

Date: June, 1990

Organizational Unit: BellSouth Corporation

Analyst: Hay/

Location: Atlanta, Georgia

Reports To: Board of Directors of BellSouth Corporation

Accountability Objective (Basic Function)

To provide leadership to the Board of Directors in carrying out its collective responsibility for the management of the assets, business and affairs of BellSouth Corporation.

To strategically plan, organize, manage and control the total operations of BellSouth Corporation and its subsidiaries in ways that result in the optimum in cost effective service, the required growth in revenues and earnings, and expansion into new international markets and new business lines, while maintaining compliance with applicable regulatory guidelines, Board policy standards, and maintenance of a viable existence within the competitive marketplace.

Dimensions

Employees:	101,230
Total Revenues	$14.2B
Operating Expenses	$12.5B
Net Income	$1.7B
Capital Expenditures	$3.2B
Total Assets	$30.1B
Service Area	9 Southeastern States

Nature and Scope

The Chairman and Chief Executive Officer of BellSouth Corporation reports to the Board of Directors. The Board consists of sixteen members, thirteen of whom are outside directors.

BellSouth Corporation is the largest of seven telecommunications holding companies and related enterprises created as a result of the AT&T divestiture. BellSouth Corporation's principal subsidiaries include:

- South Central Bell - a regulated operating telephone company servicing customers in the states of Alabama, Kentucky, Louisiana, Mississippi, and Tennessee.

- Southern Bell - a regulated operating telephone company serving customers in Florida, Georgia, North Carolina, and South Carolina.

- BellSouth Services - a company jointly owned by South Central Bell and Southern Bell providing strategic support services to these regulated companies.

- BellSouth Enterprises - a holding company established in 1986 to pursue three primary lines of telecommunications-related businesses: directory advertising and publishing; the sale and service of telecommunications and computer systems; and world-wide mobile communications operations.

The current environment of the telecommunications industry is characterized by increasingly aggressive and dynamic national and global competition, as well as rapid technological change. In the past corporate decisions focused on the ability to maintain earnings levels and to improve the efficiency of services provided. By contrast, today's corporate decisions entail greater risk due to the required early commitment of corporate financial and technological resources towards projects/business lines which may or may not provide an adequate return on investment. Issues that significantly impact BellSouth's ability to compete include: the regulatory restrictions which currently limit the business market segments in which BellSouth can expand; the financial success of alternate forms of regulation (i.e., "incentive regulation"), both for the company and the shareholder; the ability to remain at the technical forefront and compete internationally in an industry whose innovative products of today are technologically obsolete tomorrow; competing under a regulatory process against others not so constrained; the widely varying regulatory environments in the various states in the BellSouth region; and being precluded by the terms of the divestiture agreement from manufacturing equipment or forming strategic alliances with possible suppliers.

The incumbent is accountable to the Board of Directors, shareholders, and ultimately the general public for the efficient and effective management of BellSouth Corporation and its subsidiaries. Specifically, this involves cost effectively providing, through the three operating companies, the highest quality telecommunications services and related businesses, utilizing the latest in available technology. To accomplish this objective, the incumbent must select, develop, evaluate and reward key management for insightful strategic planning and the accomplishment of company goals and objectives. The incumbent must also plan and direct the company's initiatives in the areas of regulatory control, telecommunications research and development, marketing analyses and implementation, and the expansion into new business segments within the telecommunications industry.

In accomplishing this accountability the Chairman has structured a support organization with the following positions reporting directly:

President - South Central Bell -- Accountable for overall direction, planning, management and control of all elements of South Central Bell's activities in order to provide effective coordination and integration of the varied and diverse functional elements that combine to make up company operations and to produce the required levels of growth in revenues and earnings. South Central Bell employs approximately 32,000 personnel with revenues of $5.1B and assets of $11.1B and provides telecommunications services to a five state service area.

President - Southern Bell -- Accountable for overall direction, planning, management and control of all elements of Southern Bell's activities to provide effective coordination and integration of the varied and diverse functional elements that combine to make up company operations and to produce the required levels of growth in revenues and earnings for that company. Southern Bell employs approximately 46,000 personnel with revenues of $7.1B and assets of approximately $15.1B. Southern Bell provides telecommunications services to a four state service area.

President - BellSouth Services -- Accountable for efficiently providing selected technical, regulatory and staff support services to the two regulated telephone companies and contributing to their sustained and profitable growth.

President - BellSouth Enterprises -- Accountable for expanding BellSouth's presence and market share in the non-regulated portions of the telecommunications industry through innovative technology and marketing of the company's mobile communications, telecommunications and computer systems, and directory advertising and publishing services both domestically and abroad.

Executive Vice President and General Counsel -- Provides to the management of BellSouth and its subsidiaries legal counsel and advice through direction of the corporate legal department and functional direction and coordination of subsidiary legal departments.

Executive Vice President - Governmental Affairs -- Accountable for overall strategy planning and implementation before federal regulatory agencies, and for direction of BellSouth's overall congressional relations program.

Vice Chairman of the Board - Finance and Administration -- Accountable for directing corporate level strategic and financial planning efforts for BellSouth Corporation. Additionally, the incumbent directs corporate level activities in the areas of external communications, corporate human resources and provides coordination between the company's non-regulated businesses and the remainder of the enterprise.

A significant challenge currently facing the incumbent is the planning for succession of key managerial positions. Due to the long service of many senior executives, a major replacement of key managerial talent will be required over the next five to six years. These replacements will be made through internal sourcing and, in some instances, external recruiting. As the telecommunications industry becomes more complex, the requirements for the managerial positions and their incumbents have necessarily become more specialized. A critical role of the Chairman is to build and develop a top management team that will be prepared to achieve the strategic plans and goals of the organization.

Another significant challenge facing the Chairman relates to the conditions of the divestiture which mandate separation of the corporation's regulated and non-regulated businesses. The company must continue to operate on a basis which insures there will be no cross-subsidizing of the non-regulated businesses by the regulated ones. This requires very careful planning and control in order to defend the company's position in the event of charges from competitors and others.

The Chairman operates within broad policy guidelines established by the Board of Directors and applicable regulatory authorities. Within those guidelines the incumbent exercises final authority on all matters requiring major organizational, policy or budgetary decisions.

The incumbent and all direct reports serve on the BellSouth Corporation Corporate Policy Council, with the incumbent serving as Chairman of the Council. The Council meets on a regular basis to establish and review operational and financial goals, develop corporate policies and deal with major decisions. Because of the increasingly competitive environment, particularly from the non-regulated sectors, the thinking of the Corporate Policy Council must take on a more entrepreneurial style. This represents a major cultural change for the organization and a key challenge for the Chairman and the Council in the development and implementation of policies that support this culture.

The Corporate Policy Council typifies the incumbent's approach to management style. That is, the incumbent chooses to utilize a team approach in managing overall operations, which at the same time facilitates an orderly and formalized system of strategic planning and tracking. Such a forum also facilitates the internal communications required to ensure a well coordinated and integrated approach toward effective company management and direction.

As Chairman and Chief Executive Officer, the incumbent serves as the chief spokesman on behalf of the company to the various constituents with which the company must deal, including regulators, stockholders, customers, and the general public. The Chairman must relate to these various groups in a manner that puts forth a positive and aggressive image of the company and ensures effective communication.

To perform this job, the incumbent must have some business management education, as well as many years of experience managing a sizable, technical and diverse organization. The incumbent must be able to assimilate a wide variety of technical and business-related information and then formulate strategic plans, goals and objectives based on that information. This position requires the highest level of decision making in an environment that demands a high tolerance for ambiguity and great degree of risk.

Principal Accountabilities

1. Assure that BellSouth Corporation and its subsidiaries are operated in a fiscally sound and prudent manner in order to provide the best possible telecommunications and related services at a reasonable cost while simultaneously achieving required levels of growth in earnings and revenues.

2. Organize and structure the top level management team both for the corporation and its major subsidiaries in order to assure the achievement of strategic goals and objectives.

3. Select, develop, evaluate and reward key executive management throughout the corporation to assure a high level of management productivity and continuity.

4. Guide and advise top management within the organization in the resolution of significant problems that may affect the achievement of overall goals and objectives.

5. Assure the attainment of required financing for overall corporate operations.

6. Serve as Chairman of the Board and chief spokesperson to the Board on all matters requiring its attention in order to ensure effective, top level communications and facilitate the Board's decision making process.

7. Serve as the chief spokesperson on behalf of the corporation to the various constituents with which it must deal, including government, industry, the financial community, media, and the general public in order to effectively communicate the corporation's position on key issues and the services that BellSouth provides.

BELLSOUTH CORPORATION
POSITION DESCRIPTION

TITLE: Vice Chairman - Finance & Administration

DATE: December 16, 1991

ORGANIZATIONAL UNIT: BellSouth Corporation

LOCATION: Atlanta, Georgia

REPORTS TO: Chairman, CEO and President

BASIC FUNCTION:

To provide strategic guidance to the company's financial and corporate planning processes and to human resources and public relations areas in order to anticipate, prepare for and respond to business demands in ways that assure the company a competitive and profitable posture in the marketplace.

DIMENSIONS:

Total Assets	$30B
Total Revenue	$14B
Pension Fund and Savings Plan Investments	$12.6B
Long Term Capital Debt Outstanding	$7.8B
Equity Outstanding - Book	$12.7B
Equity Outstanding - Market (among top 20 U. S. corporations)	$23B
Capital Expenditures	$3.2B
Corporate Income Tax Liability	$778M
Operating Budget Administered	$248M
Number of Personnel Supervised	522
Number of Shareholders	1.3B

NATURE AND SCOPE

This position reports to the Chairman, CEO and President of BellSouth Corporation as do the Chairman of BellSouth Telecommunications, the President of BellSouth Enterprises, the Executive Vice President and General Counsel, the Executive Vice President - Government Affairs and the Vice President - Corporate Responsibility and Compliance. Reporting to this incumbent are the Vice President - Secretary & Treasurer, the Vice Preident - Corporate Planning & Budget, the Senior Vice President - Corporate Human Resources, the Vice President - Public Relations and the Assistant Vice Preident - Tax.

The internal and external environments affecting BellSouth's operations have become highly complex since divestiture. Internally, there have been nev functions added in the finance and human resources areas, including the nev requirement for the company to relate directly to the shareholder. In the external environment the scrutiny by the press and the financial community, the rapid changes in technology, the incresed involvement of government in the operations of the business and increased competition, combine to add unexpected and changing considerations to planning and the development of policies.

In order to accomplish the objectives of the company, this Vice Chairman provides support to the Chairman and has a staff organization vith the following key positions reporting directly:

Vice President - Secretary & Treasurer (77 employees)

Vhose role includes both the Corporate Secretary function and capital acquisition and cash management activities of both the regulated and unregulated segments of the corporation. Additionally, this includes surveillance and performance management of the corporation's pension and savings plan, development and recommendation of treasury policy and methods on a corporate-vide basis, banker and investment community relations, long range financial planning, interface vith the Nev York Stock Exchange and other exchanges upon vhich the corporation's stock is traded, managing shareholder services and communications, and maintaining contact vith rating agencies.

Vice President & Comptroller (83 employees)

Vhose overall accountability relates to protection of corporate assets and the proper recording and reporting of transactions vithin a system of sound internal controls. Other areas of responsibility for the Comptroller include generation and maintenance of Executive Instructions, interfacing vith the corporation's independent auditing firm, developing accounting policies, methods and systems on a corporate basis, managing corporate level accounting operations and managing the corporate insurance function. In addition, this position is responsible for the planning and provisioning of all corporate support services for the BellSouth corporate headquarters building.

Vice President - Corporate Planning & Budget (54 employees)

Accountable for formulation, communication and review of the corporate and strategic planning process for BellSouth Corporation and its entities. This includes consolidation, review and tracking of capital and expense budgets for the corporation, strategic analysis and planning.

Senior Vice President - Corporate Human Resources (124 employees)

Accountable for overall management direction in the corporate-wide design of human resources policies, procedures and practices that will assist BellSouth Corporation and subsidiaries. Functional areas include industrial relations and benefits, employment, wage and salary administration, employee assessment programs, Equal Employment Opportunity compliance, executive compensation and benefits and executive continuity. This incumbent negotiates the union contract every three years.

Vice President - Public Relations (48 employees)

Accountable for coordinating the public relations activities for BellSouth Corporation and all entities that will provide information to the customer on the BellSouth identity, implement the values of BellSouth with the employees and create proactive media relations.

Assistant Vice President - Tax (135 employees)

Who is responsible for centralized administration of a totally integrated tax function including federal, state and local taxation. The incumbent directs the research, planning for and filing of consolidated returns, as well as direct interface on behalf of the corporation with the Internal Revenue Service and state revenue departments. The incumbent also maintains a proactive role in the legislative arena in providing company positions to those bodies related to tax matters.

* * * * * * * * * *

The Vice Chairman directs the activities of these subordinates using both formal and informal methods. Each of these subordinates has their own strategic objectives and operates fairly autonomously. In most situations this incumbent utilizes one-on-one contact to direct their activities. The Vice Chairman does conduct formal staff meetings once a month to update these subordinates on corporate activities and to coordinate their efforts on major issues.

The incumbent in this position faces significant challenges in several major areas. First, the Vice Chairman is challenged by the responsibility for resolving conflicts, particularly between the regulated and unregulated segments of the business. Next, this incumbent has responsibility for assuring that BellSouth Corporation meets its financial commitment and that developmental iniatives are consistent with corporate strategies. Major challenges also exist in the Vice Chairman's subordinate areas. These include ensuring the successful operation of the planning and budgeting process; providing oversight of company-union relationships; developing programs for succession planning, particularly at the officer level, to provide upward mobility for employees; and, being an effective communicator with the external financial community.

In order to overcome these challenges, this incumbent creates new policies as necessary or may clarify company policies. Changes occur so rapidly that it is necessary to monitor policies and react to pronouncements of the Federal Communications Commission, the Department of Justice, Congress and the Financial Accounting Standards Board, as well as regulations of the Securities and Exchange Commission, the Internal Revenue Service and state laws.

Within the framework of policy and regulation, the Vice Chairman makes decisions for the corporation that are related to subordinate functions and informs the Chairman of any of these decisions of which he should be aware. Any decisions requiring Board approval, such as the commitment budget and the appointment of officers, must be approved by the Chairman before being taken to the Board.

The incumbent maintains an informal relationship with the Chairman, usually meeting in one-on-one situations. Strategic objectives are established each year and the Vice Chairman provides the Chairman with a semi-annual review and update.

The Vice Chairman serves on the Board of Directors of BellSouth Corporation and on the Strategic Planning Committee of that Board. There are frequent contacts with individual members of the Board on a variety of subjects.

PRINCIPAL ACCOUNTABILITIES

1. Organize and structure the key staff services in ways that provide efficient and profitable services to the corporation and its subsidiaries and the best use of individual and group capabilities.

2. Participate in the overall management of the corporation and its subsidiaries through membership on corporation Board of Directors and through executive assistance to the Chairman.

3. Provide overall direction to the development and monitoring of a corporate budget to assure the effective control of expenses and capital outlay that will assist the corporation in achieving its financial commitments.

4. Participate in resolution of issues between regulated and unregulated segments of the business by acting as arbitrator of disputes.

5. Provide overall direction to the corporate finance function to ensure a sound and viable financial posture for the corporation and the presence of sufficient internal controls.

6. Provide overall direction to the formulation of corporate and strategic plans so that the corporation's direction and purpose is properly defined and communicated.

7. Provide policy direction in the corporate-wide design of human resources policies, procedures and practices in ways that fulfill the corporation's and subsidiaries' current and future personnel requirements.

8. Provide overall direction to the corporation's interface in its dealings with various external constituents in ways that result in the generation of consistent and effective messages and feedback, and, in general, create a positive and favorable image for the corporation.

9. Be a good communicator and listener with subordinates and coordinate in a way that contributes to the smooth operation of BellSouth Corporation.

BELLSOUTH D.C.
POSITION DESCRIPTION

Position Title: Executive Vice President - Governmental Affairs

Code:

Date: October, 1987

Organizational Unit: BellSouth D.C.

Analyst: P. H. Saszi

Location: Washington, D.C.

Reports To: Chairman, CEO, and President BellSouth Corporation

Approvals: ____________________
Executive Vice President
Governmental Affairs

____
Chairman, CEO and President
BellSouth Corporation

Accountability Objective (Basic Function)

Accountable for developing and implementing corporate policy to achieve favorable public policy decisions at the federal level; for apprising senior management of developments that may impact such public policy decisions; for directing corporate actions to influence the course of these developments; and for enhancing the corporate image in Washington in order to assist in the attainment of corporate goals while enhancing the stature of the company as the leader in the telecommunications industry.

Dimensions

Total BellSouth Revenues:	$11.4B
Department Expense Budget:	$7.38MM
Employees:	34

Nature and Scope

The Executive Vice President - Governmental Affairs reports to the Chairman, CEO, and President - BellSouth Corporation as do the Presidents of Southern Bell, South Central Bell, BellSouth Services, and BellSouth Enterprises; the Executive Vice President and General Counsel; and the Vice Chairman. Reporting to the incumbent are the Vice President - Federal Relations and the Vice President - Regulatory Affairs. Reporting on a functional basis is the Governmental Affairs Support organization in BellSouth Services.

Prior to Divestiture all relations at the national level with Congress, the Executive Branch, and the Federal Communications Commission were handled by AT&T for all of the Bell system companies. Each of the operating companies was responsible for the Members of Congress from the states in their respective areas. Since Divestiture not only has AT&T been removed, but also the relationship between the Regional Companies and the Federal Government has undergone some dramatic changes. For example, BellSouth's involvement with Members of Congress and other branches of government now extends beyond the confines of the nine-state southeastern region. This is due to the company's involvement with new ventures, some of which have operations in other states and countries; to BellSouth's efforts to market products and/or services to the Federal Government; and, equally important, to the fact that so many in the Congressional leadership posts, affecting the interests of BellSouth represent areas outside the BellSouth territory. Also affecting the company's situation in Washington is the necessity of operating within the regulations and restrictions of the Federal Communications Commission (FCC). This situation is peculiar to BellSouth and some other telecommunications companies, and it poses a distinct set of political problems. Therefore, the objectives of this position and the Washington office include expanding the relationships with Members of Congress to include the 535 members from all of the states, increasing influence in the executive branch, and obtaining relief from the FCC in order to position BellSouth Corporation as a financially healthy, all-service provider to the customer.

The Executive Vice President - Governmental Affairs accomplishes these objectives by performing various functions personally and by structuring an organization to handle key functions. This incumbent has five major areas of accountability. The first of these is the early identification of emerging concepts in the Federal public policy arena and a professional assessment of the viability and timing of any public policy decisions that may result. Concepts of this nature can be legislative, regulatory, or executive orders by independent federal agencies.

The second major area is the determination of what impact, if any, such potential public policy decision may have upon corporate goals, objectives, plans, and policies. Where there are existing corporate policies that may be affected, the Executive Vice President establishes corporate strategy consistent with such policies and directs whatever actions are necessary to implement that strategy. If there is no existing corporate policy, the Executive Vice President consults with top management (usually the Presidents of Southern Bell, South Central Bell, BellSouth Services and BellSouth Enterprises; the Executive Vice President and General Counsel of BellSouth; and, of course, the Chairman of the Board, CEO, and President of BellSouth) in the formulation of appropriate new corporate policy and develops strategy to implement the new policy. In addition to impact assessment, it is the responsibility of this incumbent either to advocate personally, or to direct the advocacy by others of the corporate position with the appropriate government body or official(s), or other private sector groups and organizations determined to have an interest. This includes leadership positions in the legislative and executive branches and in the independent agencies, particularly with the FCC, the Congress and the White House.

The third major area of accountability is the political assessment of the feasibility of obtaining public policy decisions that are consistent with corporate goals, objectives, plans, and policies. This is critical in determining the extent to which corporate resources and expenditures are committed to influence the outcome of a public issue. Sometimes it is necessary for the Executive Vice President to decide that the advocacy of some corporate positions must be subordinated to others in order to enhance the possibility of achieving a favorable result on a more significant issue. This dimension of the incumbent's responsibility requires both knowledge of and insight into the total governmental environment together with an experienced political sensitivity in order to render informed judgments in matters of major significance to the corporation.

Fourth is the area of representing the corporation as the senior executive in the national capital area. External perceptions of this incumbent are critical to the success of corporate activity in Washington. Professional competence in government relations is the foundation for leadership of the department and is essential to the maintenance of mutual respect with policy makers and business counterparts. In the competition for corporation prestige among the business community and private sector representations, however, the Executive Vice President must also demonstrate leadership in the cultural and social communities in Washington. This dimension of the position not only enhances the corporate image with the various constituencies, but it has the potential of providing the margin of success in a corporate endeavor.

Lastly, this position serves as the principal corporate officer for all Federal government relations matters. As such, it has overall responsibility for shaping and directing corporate advocacy with all Washington based stakeholders both within and outside the government. As the principal political resource, this position also directs the activities of all corporate-sponsored Federal political action committees for the corporation's employees.

In accomplishing these functions, the incumbent must coordinate with various contacts both external and internal to BellSouth. The contacts external to the company include essentially all Washington-based stakeholders. Internal contacts include the top management employees already listed plus the Vice Chairman of BellSouth; the Executive Vice President and General Counsel of BellSouth; the Vice Presidents and General Counsels of South Central Bell and Southern Bell; the Executive Vice President - Marketing, Network and Planning (BellSouth Services); the Executive Vice President - Corporate Human Resources (BellSouth Corporation); the Vice President - Corporate Affairs and Secretary (BellSouth Corporation); the Executive Vice President and Senior Financial Officer (BellSouth Corporation); the Senior Vice President - Regulatory and External Affairs (Southern Bell); and the Senior Vice President - Revenue Requirements (South Central Bell). The purpose of these contacts is twofold. First, the incumbent must communicate with any or all of these contacts concerning telecommunications issues as well as generic issues such as tax bills or bills relating to employee benefits. Secondly, the Executive Vice President must position the Chairman and CEO of BellSouth and these other key Executives in the national scene by plugging them in with Washington leaders where appropriate.

The Executive Vice President has structured an organization as follows:

Vice President - Federal Relations (14 employees)

Position is accountable for achieving favorable public policy decisions by the U.S. Congress and independent Federal agencies (excluding FCC) including the Executive Department and the White House on matters that affect corporate goals, objectives, plans and policies. Shaping and implementation of corporate policies are integral parts of the job. Organization is responsible for development and maintenance of professional relationships with staffs of all members of Senate and House of Representatives and with those members whose constituency is outside BellSouth territory. Provides direction and leadership for advocacy by other BellSouth entities who handle member contacts for our nine state areas. Staff members also have direct contact responsibility for numerous agencies and executive departments; including State, Commerce and U.S. Trade Representatives that are essential parts of our international strategy as well as strategies of unregulated subsidiaries.

Vice President - Regulatory Affairs (18 employees)

Position is accountable for achieving favorable public policy decisions by the Federal Communications Commission and related governmental and private sector groups on matters that affect corporate goals, objectives, plans and policies. Also responsible for liaison with other industry related non-governmental organizations based in Washington such as the National Association of Regulatory and Utility Commissioners (NARUC) and United States Telephone Association (USTA). Shaping and implementation of corporate policies are integral parts of the job. Organization is responsible for development and maintenance of professional relationships with FCC commissioners and their staffs, with key members of the Common Carrier Bureau, Office of Plans and Policy at the FCC and with members of the staffs of key NARUC and Joint Board committees and USTA. Provides leadership and direction for advocacy with members of NARUC and Joint Boards who reside in BellSouth territory. Has direct contact responsibility for all others.

* * * * *

The complexity and diversity of issues monitored and forums in which influence is exerted require that each subordinate organization operate with considerable latitude. The Executive Vice President draws on expertise and knowledge of individuals as appropriate to fulfill particular requirements. In addition, the incumbent provides broad directions and specific focus where necessary. The incumbent coordinates the operations of the staff by conducting monthly staff meetings. The Executive Vice President also spends an average of two days a week in Atlanta primarily to coordinate the activities of the Governmental Affairs Support organization with the Washington office and to interface with others in the Senior Management of BellSouth Corporation and its entities.

The major challenge of this position is twofold. First, the incumbent must leverage the functions related to the 535 Members of Congress from the small base of nine states and 100 members. This involves creating relationships with members from states in which BellSouth is either not a constituent or has just recently become a constituent. Secondly, this position must endeavor to remove the regulations and restrictions of the FCC and the Federal District Court to allow BellSouth to operate and compete effectively in areas of established business as well as in those areas represented by the new ventures. Another significant challenge is to bring all of the companies that are now part of BellSouth Corporation into one political stream. This requires blending of disparate political cultures.

The incumbent is granted broad authority to operate within the functions of his position. Major policy parameters within which to operate must be approved by the Chairman; however, the methods related to operating within those parameters are all left to this Executive Vice President. The incumbent meets with the Chairman or communicates in writing on an as-needed basis to provide updates and status reports.

In addition to the duties listed, the Executive Vice President - Governmental Affairs is also the Chairman of the BellSouth Federal Political Action Committee.

Principal Accountabilities

1. Develops and implements corporate policy to achieve favorable public policy decisions by governmental bodies and other policy shaping organizations at the federal level.

2. Provides analytical and evaluation issue support to all components of corporate management to facilitate timely and effective decisions.

3. Directs the activities of the Governmental Affairs organization and reviews the strategies of staff members to ensure the Corporation's positions on federal legislation and federal regulatory issues are clearly defined and unified.

4. Assures that contemplated legislation and regulatory rulings by federal entities are recognized and addressed by the corporation.

5. Provides public affairs leadership, advice and assistance to the BellSouth entities.

6. Develops and maintains effective continuing liaison with key national policymakers to identify and evaluate significant issues in a timely manner to assure awareness of the Corporation's operations and plans.

7. Ensures a competent, motivated and developing staff is available to meet perceived short and long-term requirements. Provides training for contact people in subsidiaries on critical issues.

8. Maintains relationships with policymakers, trade associations, and representatives of other corporations in Washington to keep them informed of BellSouth's operations and plans.

9. Provides leadership and direction to ensure the corporation is recognized for its professional expertise as well as for its position as a major factor in the social and cultural communities in Washington.

BELLSOUTH CORPORATION
POSITION DESCRIPTION

Position Title: Executive Vice President and General Counsel

Code:

Date: April, 1990

Organizational Unit: BellSouth Corporation

Analyst: P. H. Saszi

Location: Atlanta, Georgia

Reports To: Chairman, Chief Executive Officer, and President - BellSouth Corporation

Accountability Objective (Basic Function)

To provide the management of BellSouth Corporation and its subsidiaries with effective legal counsel, advice and representation through direction of the Corporation's Legal Department, functional direction and coordination of subsidiary legal departments, and supervision of all outside counsel employed by BellSouth companies; to participate in the overall management, guidance, and policy making for the Corporation by serving as a member of the BellSouth Corporate Policy Council; and to make the legal function operate as one for all companies.

Dimensions

Total Operating Revenues BellSouth and Subsidiaries:	$14.2B (1989)
Legal Department Operating Budget:	$40.3 MM (1990 Budget)
Outside Counsel Fees:	$10.4 MM (1990 Budget)
Personnel Supervised:	138 Attorneys (Total System)

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Nature and Scope

The Executive Vice President and General Counsel reports to the Chairman, Chief Executive Officer, and President as do the Vice Chairman - Finance and Administration; the Executive Vice President - Governmental Affairs; and the Presidents of BellSouth Enterprises, BellSouth Services, Southern Bell, and South Central Bell. This position serves as the top legal officer within the BellSouth Corporation, a role which encompasses management of the Corporation's inhouse legal function, including direction of the legal functions in each of the corporation's subsidiaries, management and/or coordination of outside legal services retained on behalf of the Corporation or its subsidiaries, and participation with other key executives in the efforts of the Corporate Policy Council. The incumbent accomplishes this personally and through a legal staff which consists of the following positions that report directly:

Vice President and Associate General Counsel

Who acts as deputy to the General Counsel and is directly responsible primarily in the area of the legal aspects of regulatory matters affecting the Corporation and its subsidiaries. The Associate General Counsel fulfills a coordination role in this area, ensuring that appropriate interface is established and maintained between the Federal Communications Commission (FCC) regulations and the terms of the Consent Decree and the Corporation's subsidiaries. The incumbent works closely with legal staff and other management within the subsidiaries to ensure consistent interpretation and coordinated efforts in dealing with all legal affairs of the Corporation and its subsidiaries.

General Attorney - Regulatory

Who concentrates in the area of FCC regulations and guidelines and other Federal regulatory matters, as well as coordination of state regulatory matters.

General Attorney - Antitrust, Intellectual Property and Litigation

Who specializes in Federal Courts and Department of Justice matters affecting the Corporation and its subsidiaries, providing guidance, interpretation and advice on issues arising from these bodies and from general antitrust law problems; also, providing direction on intellectual property matters and major general litigation throughout all entities.

General Attorney - Corporate

Who specializes in corporate law, i.e., securities, issues, Securities and Exchange Commission rulings and compliance, and matters relating to corporate governance of the corporation and its subsidiaries. Also provides support in mergers and acquisitions and guidance and direction of litigation resulting from such transactions.

General Attorney - Tax

Who specializes in corporate tax law, providing guidance on tax matters from a legal standpoint. Also directs state and local, ERISA, the tax aspects of benefits and manages major tax litigation throughout all entities.

General Attorney - Human Resources Matters

Who specializes in labor law and works primarily in providing guidance and advice to the Corporation and its subsidiaries on matters relating to Human Resources.

Members or subordiates of the above outlined organization may from time to time serve in a project manager capacity in conjunction with the legal staff within the subsidiaries where problems or issues arise in their specialty area.

Additionally, the Executive Vice President and General Counsel provides guidance, functional direction and support to the Chief Legal Officer in each subsidiary, including concurrence in all hiring, career planning, promotion, and compensation of lawyers in all entities. He counsels with them on administrative matters, broad corporate policy matters, apprises them of obligations arising on a national basis (e.g., FCC, Justice Department) and meets frequently with them to discuss regional direction and objectives. As needed, he will provide assistance and support to the subsidiary General Counsels in dealing with their management.

Much of the incumbent's time is spent interacting with others, both within and outside the legal organization. He usually confers with the Chairman on a daily basis, keeping him/her informed of and receiving input on major issues of current concern. He regularly meets with members of his staff to remain up to date and advise on work being conducted in their specialty areas. He meets regularly with the Legal Management Committee, which consists of the General Counsels of all major entities, and with which he consults in performing his duties. He meets occasionally with legal heads of other regional companies to share experiences and generally stay informed on areas of common interest. Additionally, personal time is spent reviewing court and commission decisions, reviewing and following up on correspondence from management requesting advice and concurrence on legal questions, and making himself available to management to provide advice and counsel on legal questions they may have. He will make personal appearances before the Justice Department and the Courts (though usually not in a formal manner) representing the Corporation's position on various matters before those bodies.

The incumbent serves as a member of the BellSouth Corporate Policy Council. The council is chaired by the Chairman. Also serving on the Council are the Presidents of the two operating subsidiaries, the President of BellSouth Enterprises, the Vice Chairman - Finance and Administration and the President of BellSouth Services. The primary function of the Corporate Policy Council is to set operational and financial goals, develop corporate policy and financial strategies. The incumbent provides input to fellow Council members from a legal perspective, as well as participating in general business decision making.

In accomplishing the position's overall accountabilities, the incumbent employs management practices designed to provide the most efficient and effective means of responding to corporate needs while at the same time ensuring the safeguarding of Company interest. This includes coordinating all legal jobs in all of the subsidiaries to assure provision of consistent advice.

The incumbent is afforded wide latitude in exercising the responsibilities of his office. He is regarded as the chief legal counsel of the corporation and thus is looked upon as the key advisor with regard to any and all legal questions that may arise. His membership and participation on the Corporate Policy Council further exemplify his role in the overall strategy formulation of corporate policy.

Page Four

Principal Accountabilities

1. Organize and staff the BellSouth legal department throughout all entities in ways that result in the optimum utilization of legal talent and an ongoing response to needs of the company for legal services.

2. Ensure that the rights and obligations of the BellSouth Corporation and its subsidiaries are met from a legal perspective; to advise senior management of matters requiring their attention, thereby averting the possibility of adverse consequences occurring against the company.

3. Represent or manage the representation of the company in all legal proceedings to ensure that its rights are protected and its case properly presented.

4. Maintain an up-to-date awareness of legal precedences and rulings to ensure that the company is equipped with the most competent and effective legal advice available.

5. Ensure the most efficient and cost effective use of outside counsel in representing the Company's interest.

6. Ensure that the Company's ventures into new non-regulated businesses are proper with regard to the Federal Court's decree and that such ventures are sound from a legal standpoint.

7. Provide overall coordination and direction to the entire legal function of the BellSouth subsidiaries so that those companies maintain a competent, effective, and consistent legal representation.

John L. Clendenin

Speech to N.Y. Financial Community

February 4, 1992

Good morning.

We in the southeastern part of the country have seen some dramatic events in the last couple of years.

Atlanta getting the 1996 Olympics surprised a lot of people around the world. But that wasn't the biggest surprise -- at least not for baseball fans like me.

I thought the Braves had taken out a mortgage on the cellar. But they came out of there with a vengeance and, along with the Minnesota Twins, treated us to a classic World Series in 1991.

BellSouth had a solid year, too -- admittedly, not a spectacular one like the Braves. But then, thankfully, we didn't have as far to go as the Braves, either.

Like a professional team that uses its draft picks to build for the future instead of trading them for a quick fix, we're committed to managing BellSouth for the long term.

We're playing to our strengths in technology and people.

We're investing aggressively in evolving opportunities domestically and around the world.

We're streamlining and realigning every structure in our corporation for greater efficiency.

And we're working diligently to influence new long-range regulatory and competitive structures, even when they involve a near-term hit on earnings.

But, as the price of pursuing these and other long term goals, we have expected and are experiencing a period of flat-to-down reported earnings.

That doesn't mean we're satisfied, and let me assure you that we're doing all we can to put a positive slope back on that earnings curve, but it will take time.

Today I plan to tell you about what we're doing to develop and strengthen what we believe is as good a mix of wireline and wireless capabilities as anyone can offer. In the world we see developing, this flexibility is what it will take to capitalize on the exploding demands for telecommunications around the globe.

Domestic and international wireless are indeed key components of BellSouth's growth strategy. And, we're well positioned in these emerging markets, both geographically and from a marketing standpoint.

We can offer the customer almost anything on the wireless continuum -- from tone-only paging, to fast-handoff, to fully featured cellular. In between are numeric and alphanumeric paging, mobile data, and experimental Personal Communications Services, or PCS.

Geographically, we now have as many cellular POPs outside the U.S. -- some 36 million in nine countries -- as we do in the 54 metropolitan markets we serve in this country.

Counting our subscribers worldwide, we put our one millionth cellular customer on the air in December. We have passed the millionth customer milestone in paging, too, thanks to our recent acquisitions.

Wireless is now a primary driver of BellSouth's growth.

Our domestic mobile - that includes cellular and paging businesses - became solidly profitable in 1990. In 1991, mobile revenue increased 37 percent, to almost $900 million. Despite the recession, net income improved 50 percent, to $57 million.

The number of our cellular subscribers grew 49 percent. Even without acquisitions, it was still a strong 46 percent growth rate.

Incidentally, to help our owners get a better understanding of how wireless fits into BellSouth's overall strategy, beginning with first quarter 1992 numbers, we are providing additional information about our cellular and paging operations both domestically and internationally.

As you know, we were active in the acquisitions market last year. Domestically, we finalized deals with GTE, Graphic Scanning and McCaw. These solidified our control or gave us added interests in 22 of our 54 markets.

And as part of the RAM Broadcasting joint venture I'll talk more about later, we have a deal pending that will give us a majority of the non-wireline license in Honolulu.

All told, we are in 13 of the top 50 U.S. cellular markets. These include such major markets as Los Angeles, Houston, Miami, and Atlanta.

Overseas in wireless, we have focused our investments in areas with good growth potential and acceptable political risk.

In Latin America, we saw the potential early and teamed with excellent partners.

In less than two years we have built systems from the ground up in Argentina, Mexico, Venezuela and Uruguay, and have purchased an operation in Chile. And we are exploring additional locations.

Because of the condition of some of the landline systems, cellular is highly demanded in Latin America, especially at the upper end of the market.

In the U.S., three out of five cellular phones are car-mounted, but in Latin America, four out of five are portable.

As a result, there is a landline substitution effect, and average air time in Latin America is considerably higher than it is here. Usage approaches 400 minutes per month in Argentina, for example, and although the other countries are not quite that high, they do exceed U.S. levels.

Due to this higher usage, our company in Argentina became net income positive in only its second full year of operation, something you don't see in the U.S.

And this growth is not limited to Argentina. In Venezuela, our new system, at year end, had added 16,000 customers since being turned up one month earlier. At this rate -- which is more than 500 per business day -- we are a year ahead of plan.

In other parts of the world, we have been awarded a cellular license to serve New Zealand. When operations commence late this year, the system will be fully digital and fully compatible with the networks we'll soon be building in Australia.

In Europe, we own 29 percent of a consortium selected by the Danish government to build and operate Denmark's first state-of-the-art digital mobile phone network. Service will be initiated in Copenhagen during the second quarter.

Dispite our emphasis on wireless, our plans to grow earnings through strategic cross-border investments include the right wireline opportunities, too, and Australia is our biggest international deal to date. More than being the biggest, the Australian consortium, called Optus Communications, is unique in many ways.

Due largely to its relative isolation, Australia is communications intensive. The telecommunications sector of an otherwise so-so economy has been expanding just under 10 percent annually.

Starting on Day One in fourth quarter '92, customers will be able to access the Optus network by dialing only one additional digit. Interconnection will be provided to Optus by Telecom Australia initially, at direct costs.

And we were granted a waiver from the long distance restrictions of the MFJ for the trans-pacific portion of the traffic between the U.S. and Australia.

This is the first general carrier's license in the world issued to build a competitive nationwide telecommunications system from scratch.

We can integrate the latest digital technologies across wireless and wireline services. We can develop our own operating systems to support our marketing efforts in a coordinated fashion.

We won't be burdened with an investment that's obsolete, or a structure that's hidebound. That's one way this project differs from a privatization.

Optus will offer a full range of network services, including domestic and international long distance, mobile, personal communications services, private line and private network.

But this is more than just a wireline opportunity.

The Australian cellular market has one of the highest growth rates in the world, with 2 percent penetration of the population since starting in 1987. The U.S. cellular penetration rate is comparable, but it's taken about twice as long to get there.

Optus will roll out the first component of its mobile services in the second quarter by reselling capacity on the existing monopoly analog network.

By early next year, Optus plans to start marketing its own cellular services. We'll have the only GSM digital network in the South Pacific, and we'll be able to provide international roaming between Australia and our system in New Zealand.

Over the next five years, Optus will invest approximately 3.1 billion U.S. dollars. About half of that will be internally generated.

BellSouth expects to put in capital of up to $300 million over the next four years.

BellSouth first became involved in Australia five years ago. We are the largest provider of paging services on that continent, so we are no strangers to the market.

But now with our 24-and-a-half percent of Optus, and our consortium in New Zealand, BellSouth has a much stronger presence in the southern end of the Pacific Rim, and we are interested in future opportunities in that emerging region.

In a move that will significantly expand BellSouth's wireless product line, we formed a joint venture with RAM Broadcasting Corporation to own and operate mobile data communications networks worldwide.

We think wireless data networks will be to computers what cellular is to phones. Our research, and that of others, identifies 10 million potential wireless data users in the increasingly service oriented U.S. economy.

RAM uses an intelligent network technology called Mobitex, developed by Ericsson and Swedish Telecom. It has lots of applications -- computer-aided dispatch, two-way alphanumeric messaging, electronic mail, transaction processing, remote data entry and retrieval, and automatic vehicle location.

You're probably familiar with at least one mobile data network here in the U.S. -- that's the one Federal Express uses to keep track of where a package is at any given instant. That's a private system.

The system we will operate with RAM will be public. The only thing like it in this country is IBM's and Motorola's venture called ARDIS.

A big difference between the two is that customers on the BellSouth/RAM system will be able to use a variety of communication devices to access the network. ARDIS is presently tied into just one manufacturer.

This flexibility for our customers is integral to our strategy. We think the joint venture company can become the platform for a software driven, nationwide, packet switched data network that end users access through a vast array of wireless terminals.

It will be a public network. But as far as the customer is concerned, it will behave like a very cost-effective virtual private network.

The shared network aspect opens up important markets for us. We will be able to price the services so smaller companies will be on a more equal footing with their larger competitors for wireless data solutions.

We think Mobitex has the potential to become a worldwide standard, and we are already aggressively going after opportunities in markets around the globe.

The new BellSouth/RAM entity already has paying customers in the U.S. and U.K. Some firms are deploying the services throughout their operations. Most are doing more limited field tests.

We are in the construction stage of our RAM network in the U.K., and we are in various stages of business development in Europe and other countries. To develop RAM's networks in the U.S. and the United Kingdom, we will provide more than $300 million in equity funding to the joint venture.

Establishing beachheads in emerging wireless and wireline markets around the world doesn't come without short-term costs. For BellSouth, those costs will cause overall dilution of about 40 cents per share in 1992, and there will be dilution next year, as well. But like a sacrifice bunt in baseball, these investments advance our team's strategic position.

With all new technologies, we believe that the most vital question is <u>not</u>, How do they work? ... but, What do they <u>do</u>?

We firmly believe that <u>services</u> are more important than the technology itself.

Customers care about applications. For example, in Orlando, we are currently testing what people want by simulating a PCS environment.

Working with Motorola, we modified portable MicroTac phone equipment to provide PCS-type services to operate on our existing cellular band. In effect, we are trialing PCS under actual selling and marketing conditions.

We are offering flexibility in pricing and customized calling options with "DriveAround," "WalkAround," and "OutBound" service to roughly 750 customers over about a 10-month time frame. It's the first and only test of its kind.

Our commitment to providing the full continuum of wireless services for voice and data has put BellSouth in the forefront of PCS development. And we're concentrating on what customers need, not on what engineers can do.

Our confidence in the long-term earnings potential of BellSouth's businesses extends to our regulated operations. We are implementing strategies to grow and market our sophisticated network, even as local exchange services become more competitive.

Underlying our efforts is a pragmatic regulatory strategy.

We recognize the political reality that regulatory change is a gradual, evolutionary process. It seldom keeps pace with the headlong rush of technology and other market forces.

We've made progress along the regulatory continuum. Seven of our nine states, representing about 80 percent of our access lines, have implemented alternative regulatory plans that feature sharing of profits above specified ranges between customers and shareholders. We have shared in Alabama, Kentucky and Mississippi.

But this progress has come at a cost. Incentive plans have been coupled with rate reductions and adjustments in targeted rates of return, and we expect continued regulatory scrutiny in 1992.

There is no question that these plans, in the aggregate, have punished earnings. But there would have been rate reductions in recent years, anyway, if we had stayed with traditional rate-of-return regulation.

That's a fact of life. Going forward, these regulatory plans give us upside potential.

At the federal level, we have booked $16 million for our portion of sharing the benefits of price caps with our customers, the long distance carriers.

This win-win scenario is precisely what the FCC intended when it instituted price caps at the beginning of last year.

Of course, I can't leave the topic of regulation without mentioning the MFJ. We are encouraged by the courts' allowing us to move forward in information services, and by the momentum in Congress behind *manufacturing relief*.

But these issues can be moving targets on Capitol Hill, because, as you know, some special interests would like to limit consumers' choices and prevent us from competing.

We are encouraged, however, that the progress over the past year, plus the FCC's recent initiatives with so-called Video Dial Tone, suggest that artificial barriers to market entry will tend to erode over time, as they should.

The FCC's *decision last month* to allow BellSouth Telecommunications in Georgia to resume sales of MemoryCall, our voice mail product, was another significant step.

As these barriers do come down, our track record should give our shareholders some assurance that BellSouth will not swing for the fences at every pitch that comes near the plate.

We listen to what customers are telling us, and that helps keep our focus on market opportunities that will build long-term value. Our investments at the margin will continue to be well reasoned and will focus around our experience and capabilities.

But as you are well aware, having new regulation and new opportunities isn't enough. We have to market our services more effectively, and we must continually increase productivity and efficiency.

That's where our strategies to streamline our organization and generate new revenues from our core business come into parallel with our regulatory strategy.

Last year, we reduced management ranks by more than 4,000 through voluntary programs. The incremental savings from that should be about $160 million this year.

Overall, our telephone employees per 10,000 access lines went down to 45.5 in 1991 from 49.1 in 1990, our largest annual percentage decrease since divestiture.

For most of 1991, we ran our telephone operations under a new unified management structure now headed by Frank Skinner as CEO and Duane Ackerman as president and chief operating officer. We legally merged the three former entities into BellSouth Telecommunications, effective January 1.

The reasons for restructuring and cost reduction are simple -- to serve our customers more efficiently, and to price our state-of-the-art services more competitively in a freer marketplace.

On the volume side, the local exchange region we serve continues to be a plus for us, and following the lingering effects of the recession, we expect access line growth in the Southeast to continue to outpace the rest of the country. Our 3.2 percent gain in 1991 set the pace for the BHCs.

BellSouth continues to be a pacesetter in deploying new network technologies, enabling us to get more out of the backbone of our business. We gain efficiencies, and we continue to bring new Information Age services to our customers.

We completed 100 percent deployment of stored program control switching more than a year ago, and more than 80% of our switches are digital.

About 57% of our access lines now have digital transmission capability and over 75% are equipped for CCS7.

With fiber optics now the most economical choice for much of our network, we have more than 765 thousand miles of fiber in place. We are committed to the full scale volume deployment and commercialization of ISDN.

And we're developing creative new approaches to marketing the power of our network. In South Florida, for example, we are working with McCaw to interconnect our network with their wireless switches using Signaling System 7. This is only a technical trial at this stage, but it may turn out to be a glimpse into the future of this industry.

The BellSouth network is a platform of operating leverage for services like MemoryCall, our voice mail product, and TouchStar, a feature package that gives customers convenience, security and flexibility at a great price.

We market Caller ID as part of the TouchStar package, and it has been deployed in 30 major markets. It has limited approval in all nine of our states.

Through December, we had sold some 1.9 million TouchStar features, more than any other Bell holding company by far. We are learning a lot about marketing from selling products like Caller ID, even as we add vertical revenues on existing lines.

We believe that in the future information services should enhance the growth opportunities in our core business, as well, and we are moving forward rapidly to trial them.

At this early stage of development, we do not view information services as a stand-alone business. Rather, we see the ability to deal in *content* as a *critical enhancement* to our current offerings.

Again, we're not going for the home run when all we need right now is a base hit. To find out what the market wants, we will be conducting limited market trials of specific information service offerings. If the test markets prove out, we'll proceed with *limited deployment* later this year, and methodically build up to wider deployment in 1993 and beyond.

Our strategy in information services has three major elements:

First -- we'll concentrate on advanced messaging and transaction services. There is strong market interest; we're already involved in these services; and both are heavily dependent on networks.

Second -- we'll provide services that evolve primarily from our core businesses.

Third -- we'll develop strategic alliances with providers whose skills in applications development match our own expertise in network management. We just acquired Scientific Software, for example, to bolster our capabilities in systems integration.

Ladies and gentlemen, last month we observed the 10th anniversary of the consent decree that led to the breakup of AT&T and the Bell System.

I remember with amusement the predictions that BellSouth would never be much more than a stodgy local monopoly utility.

But just like no one predicted that the Braves and Twins would make it to the World Series, we could not anticipate in 1982, nor can we foresee today, all the monumental changes that lie ahead in telecommunications.

Is this business more competitive than it was at divestiture? You bet it is.

But the other edge of that sword is future growth potential, and we are excited about the way we're managing these changes at BellSouth looking toward that furture.

We're investing in evolving opportunities in mobile data and other wireless opportunities around the world, just like we did in cellular in the U.S.

We're going to streamline further.

We're looking at every job, and asking if it's really necessary in this new environment. We're looking at every new technology, and asking if it will really create solutions for our customers.

We're proving the case for regulatory pricing plans that reflect the immutable forces of technology, economics and competition.

We're alive and well in the wireline business. Yes, we have competitors now, but many of them can also be our customers. And, hopefully, we'll continue to be allowed to enter new markets and become a network of networks.

We could have grown earnings faster in the short run -- by, among other things, being less aggressive with acquisitions and investments -- but that would not have been in the best long-term interests of our owners.

As the Street consensus indicates, 1992 is not expected to be a grand slam year for BellSouth.

However, our strong balance sheet and healthy cash flow give us confidence that BellSouth has the financial resources to make the investments and stay the course when the long-term potential is clear and substantial.

I believe we're making the right investments, and I can assure you, we will stay the course to achieve sustainable earnings growth.

Thank you.

He wrote 56 books, won the Nobel prize, and saved his country. Not bad for an amateur painter.

The ability to do more than one thing well is often the difference between competence and excellence.

In the case of Winston Churchill, it was the difference between excellence and brilliance.

As a war correspondent, he won renown for his courage, escaping from a Boer prison camp in South Africa and crossing 300 miles of enemy territory. As an outspoken Cabinet Minister, he championed the development of the military tank.

As a historian, he won the first Nobel prize for Literature ever awarded for the quality of the *spoken* word as well as the written word.

As a politician, he personified the will of a nation, leading Britain to her finest hour.

And at his truest love — painting — his talent surprised the critics and his landscapes were hung in the prestigious Royal Academy of Arts.

Yet it wasn't any one of those abilities, but all of them brought together, that made Churchill the stuff of which legends are born.

And if you understand how that combination of truly remarkable talents can lead to excellence, you'll understand the vision of BellSouth.

Individually, the companies of BellSouth are counted among the best in their field. And when brought together to help you, they can provide integrated solutions to a surprising variety of problems.

HERE'S HOW THE COMPANIES OF BELLSOUTH INTEGRATED MANY TALENTS TO HELP MULTI-LOCATION BANKS.

Developed a cash management service utilizing public videotext network capability.

Assisted in acquisition, implementation and maintenance of advanced technology for retail delivery system in branch locations.

Integrated automatic number identification technology allowing a customer to access his database records through bank-based systems integration software focused on inbound telemarketing, customer service and technical support.

Offered 1.544 megabit data transport between large banking centers and headquarters' mainframe for cost effective, reliable data communications.

Senior industry executives named BellSouth the most admired telecommunications company in America for the past three years in an annual *Fortune* magazine survey. Which means if you're looking at your own business and personal communications needs, the companies of BellSouth may be just the kind of partner you're looking for.

After all, when you can surround a problem with remarkable talent, successful solutions can't be far away.

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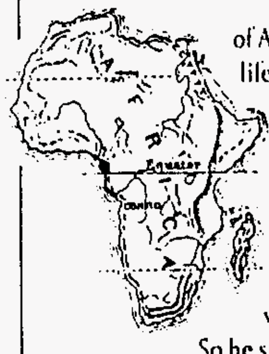
Take away his writing, his philosophy, and his music and he was just another country doctor. In his case, a whole country.

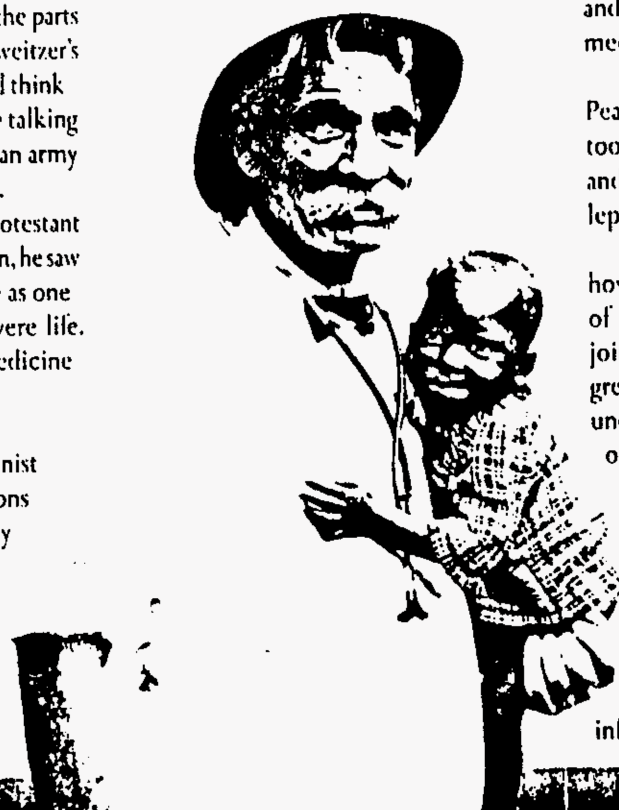


Add up the parts of Albert Schweitzer's life and you'd think you were talking about an army of men.

As a Protestant theologian, he saw medicine as one way to revere life. So he studied medicine and went to work in French Equatorial Africa.

As a classically trained organist renowned for his interpretations of J. S. Bach, he raised money for his hospital by giving concerts.

As a philosopher and writer he was renowned for his prodigious work, *The Philosophy of Civilization,*



and used the royalties to purchase medical supplies.

And after winning the Nobel Peace Prize in 1952, he took the award money and built a village for leprosy patients.

If you understand how that combination of remarkable talents joined to serve one greater purpose, you'll understand the vision of BellSouth.

HERE'S HOW THE COMPANIES OF BELLSOUTH INTEGRATED MANY DIFFERENT TALENTS TO HELP ONE OF THE WORLD'S LARGEST RETAILERS.

Designed systems to utilize network intelligence to more effectively manage incoming customer calls and agent utilization.

Accepted order to place several thousand telephone systems in locations throughout the U.S.

Implemented an asset management tracking system to log maintenance on data terminals at all locations.

Supplied mobile phone service to field technicians to reduce backhaul.

Utilized data communications to lower overhead on credit card purchase transactions by 50%.

Individually, the companies of BellSouth are counted among the best in their field. And when brought together to help you, they can provide integrated solutions to a surprising variety of telecommunications and information problems.

Senior industry executives named BellSouth the most admired telecommunications company in America for the past three years in an annual *Fortune* magazine survey. Which means if you're looking at your own business or personal communications needs, the companies of BellSouth may be just the kind of partner you're looking for.

After all, when you can surround a problem with remarkable talent, successful solutions can't be far away.

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Attachment MLB-5
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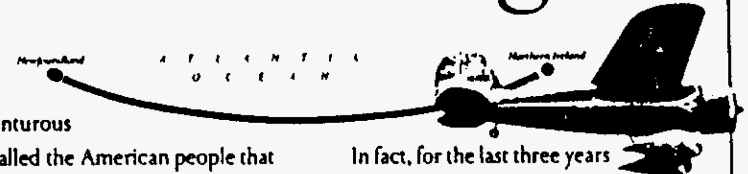
She became the first woman aviator to cross the Atlantic, an author, entrepreneur and nurse. Just what you'd expect from a fashion designer.

Some say things can't be done. Others do them, proving that with the right combination of bravado and talent, there's no telling what you can accomplish.

Nicknamed "Lady Lindy," Amelia Earhart was not only the first woman to fly solo across the Atlantic, she held women's speed and distance records that earned her place as the first woman to receive the Distinguished Flying Cross.

As a nurse during World War I, Earhart developed an early concern for her fellow man that helped her champion human rights around the world. Her memorable accomplishments in the air moved her to pen three best-selling books. She served as aviation editor for *Cosmopolitan*. She designed and marketed a line of luggage and founded two successful airlines. An admired poet, she inspired two popular songs and even a foxtrot aptly called the Earhart Hop.



Her adventurous lifestyle so enthralled the American people that she created fashions for top department stores like Macy's and Marshall Field's.

If you understand how Amelia Earhart combined many talents in her pursuit of excellence, you'll understand the commitment of BellSouth.

Individually, the companies of BellSouth are considered to be some of the best in their field. Brought together to serve your needs, they can provide technologically advanced solutions to a variety of problems in health care, manufacturing, retailing, banking, government and others.

HERE'S HOW BELLSOUTH INTEGRATED MANY DIFFERENT TALENTS TO HELP THE HEALTH CARE INDUSTRY MEET ITS COMMUNICATIONS NEEDS.

Developed a system for electronic insurance claims processing utilizing an advanced interactive network, reducing overhead costs and handling time.

Created disaster recovery systems employing network and cellular services.

Designed an interactive network linking medical centers, physician groups, insurance companies and employers to achieve a significantly higher level of cost effectiveness in the provision of services.

In fact, for the last three years in an annual *Fortune* magazine survey, senior industry executives have chosen BellSouth as the telecommunications company they most admired in the United States.

Which means if you're looking at your own business or personal communications needs, it's quite likely you'll find the companies of BellSouth to be exactly the kind of partner you're looking for.

Because after all, when you surround a problem with remarkable talent, there's no telling how far you can go.

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After being an author, a professor and championship athlete, he was finally in a position to change the world.

Some people have a talent for helping those whose lives they touch. But few have a wealth of talents that can help the entire world.

Ralph Bunche always wanted to teach. So he became a professor at Harvard, and later, the chairman of the political science department at Howard University.

He authored two books that look at race relations throughout the U.S. and the world.

In the 1940s, Bunche became recognized as an expert in international affairs. As a noted statesman and negotiator, he helped establish the United Nations' role as a peacekeeper by leading the commission that eased the Arab-Israeli conflict in 1949.

Throughout his life, Ralph Bunche earned many honors. In 1950, he was awarded the Nobel Peace Prize and, in 1963, the Presidential Medal of Freedom. In addition, he received more than fifty honorary degrees from colleges and universities around the world.

He once said that his most prized possessions were three gold basketballs, trophies which he received at UCLA where he was a starting guard on three consecutive Pacific Conference championship teams.

If you understand how Ralph Bunche used his unique combination of abilities to meet and excel at many challenges, you'll understand how BellSouth is committed to using its many different talents to meet the needs of its customers.

HERE'S HOW THE COMPANIES OF BELLSOUTH INTEGRATED MANY DIFFERENT TALENTS TO HELP STATE GOVERNMENTS.

Designed an integrated telecommunications and information systems solution utilizing telephone systems, computers, gateways and voice mail to support a state lottery system.

Linked together key locations across the state with a digital data network for transmission of important documents with customer control of network configuration.

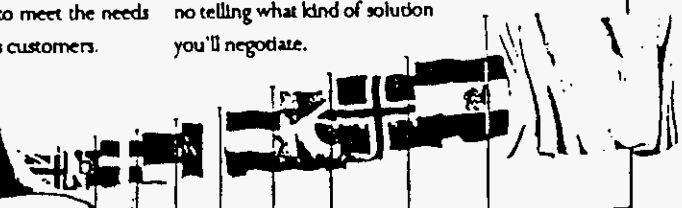
Modernized the state capital communications system by installing a state-of-the-art digital switching system.

Individually, the companies of BellSouth are considered some of the best in their field. When brought together, they can provide technologically advanced solutions to a variety of problems in government, banking, retailing, health care, manufacturing and many others.

In fact, for the past three years in an annual *Fortune* magazine survey, BellSouth was chosen by senior industry executives as the most admired telecommunications company in the United States.

Which means if you're looking at your own business or personal communications needs, the companies of BellSouth may be just the kind of partner you're looking for.

After all, when you can surround a problem with more than one remarkable talent, there's no telling what kind of solution you'll negotiate.



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BELLSOUTH

"CHURCHILL"

COMM'L NO.: YOBB 0609

LENGTH: 60 SECONDS

(MUSIC UNDER THROUGHOUT)

FIRST MAN: Churchill was one of the greatest leaders

the world's ever had.

SECOND MAN: He got the Nobel Prize for oratory and for writing.

He was a great statesman.

THIRD MAN: Oh, Churchill loved to paint.

He always said that he did his best thinking with a brush in one hand, and a cigar in the other.

FIRST MAN: He was an innately brave man; he was totally fearless. The moment he realized the importance of the airplane, he got a pilot's license. Typical of the man.

ANNCR: (VO) The sum of Winston Churchill was much greater than the parts.

Because real greatness is doing more than one thing well. That's the vision of BellSouth. To be a network of companies doing a lot of things well.

To help manufacturers, state governments and others do what they do even better.

BellSouth

(MUSIC)

(MUSIC)

(MUSIC)

Everything you expect from a leader.

F01A03Z003176

BELLSOUTH

"SCHWEITZER"

COMM'L NO.: YOBB 0611

LENGTH: 60 SECONDS

(MUSIC UNDER THROUGHOUT)

FIRST WOMAN: Albert Schweitzer was a genius.

FIRST MAN: He was a writer, philosopher, missionary, and a physician.

And he was brilliant at all of them [illegible]

SECOND WOMAN: My father wanted to be in command of things

so he was the doctor in charge of the hospital. He was also the builder of the hospital.

FIRST WOMAN: He also gave concerts all over Europe as an organist.

He could play a Bach organ fugue with such power.

SECOND WOMAN: It comes all together through his philosophy of reverance for life.

ANNCR: (VO) So many skills wrapped inside one man, together they made Albert Schweitzer's greatness. That's the vision of BellSouth. To be a network of companies doing a lot of things well.

To help retailers, health care, banks and others do what they do even better.

BellSouth

(MUSIC)

(MUSIC)

(MUSIC)

Everything you expect from a leader.

F01A03Z003177

BELLSOUTH

"AMELIA EARHART"

COMM'L NO.: YOBB 1601

LENGTH: 60 SECONDS

(MUSIC UNDER THROUGHOUT)

FIRST WOMAN: Amelia Earhart and I both set records flying airplanes. But, she flew a little further into history.

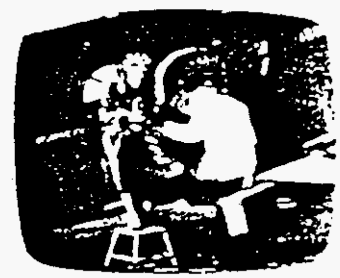
FIRST MAN: As Amelia's mechanic,

I knew when she set out to do something she was gonna do it.

She thought everyone should fly, so she helped start an airline.

SECOND WOMAN: My sister was a gifted speaker,

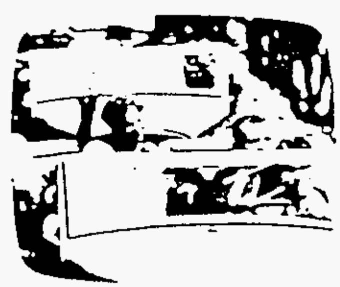
she was an author and a magazine editor.



FIRST WOMAN: And she designed luggage which is still being sold,

and she even designed clothing. And most people just thought she flew airplanes.

ANNCR: (VO) If you understand how Amelia Earhart combined many talents in her pursuit of excellence, you'll understand the commitment of BellSouth.



To be a network of companies doing a lot of things well. To help health care, state governments and others do what they do even better.

BellSouth.

(MUSIC)

(MUSIC)

(MUSIC)

Everything you expect from a leader.

BELLCORE Project Profiles
Public Counsel Proposed Disallowance
Project Numbers Included:

021411
421301
421302
421303
421306
621204
621306
621307
621405
621406
621408
621409
821101
821102
821103
1R3521
1R4111
1W0111
1W0211
1W1511
1R2112
1R3011
1R4127
1R501N
1R502X
1R1311
1R3111
1R4211

Project Name: **SYSTEMS INTEGRATION**
Project No.: 021411

Bellcore Product Manager: **A. BERGH**
Tel. No.: (201) 829-4938

This Project is a Component of the Bellcore Product: **APPLIED RESEARCH**

Significant Change Date: 08/30/90

PROJECT OVERVIEW:

This project addresses the integration of services and network technologies for the future communications environment in which an intelligent, broadband exchange network will be the heart of an infrastructure supporting a wide range of user needs and equipments. Beginning from the premise that a heterogeneous collection of networks, terminals and applications must work together as one information networking infrastructure for the Information Age, this project furthers understanding of the capabilities required in the exchange network for its role as the foundation and intermediary of a public communications system that truly meets personal, organizational, and social needs. The networking systems and technologies explored by this project are stressed, along with services and applications to investigate new and more effective ways of dealing with the challenges of a multi-services, multimedia, multi-network, multi-terminal, and multi-user communications environment.

Specifically, the project investigates and constructs experimental research prototypes of local exchange systems, signaling, and software supporting multi-services, multimedia, multi-point user applications of the future Broadband Integration Services Digital Network (BISDN). It further investigates and prototypes local distribution networks that would be used to extend the public network interface to multiple subscriber equipments, and internetwork of local and metropolitan area networks with the local exchange. Particular attention is directed to the systems-level applications of emerging high-speed electronic and optical technologies. It further studies the performance of experimental prototypes of advanced services, such as packet video, multimedia teleconferencing, and high-speed connectionless data transport, in its testbeds. It explores network operations issues such as monitoring, traffic control and billing. And it offers other research groups experimental testbeds for services, applications, user interfaces, and network control concepts and technologies.

The knowledge generated by this project has impacts on Client Company exchange businesses through several mechanisms. Coordinated prototyping is carried out with Information Networking Services and other areas of Bellcore that work with the Client Companies on new services, network evolution, and operations. Hardware and software research prototypes are transferred directly to the Client Companies, Pg 3·

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SYSTEMS INTEGRATION

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021411

PROJECT OVERVIEW: (CONT.)

and information is transferred through demonstrations, talks and publications. Finally, this project encourages, through collaborations with industrial and other research laboratories, research and development important to the future information networking environment.

The benefits to the Client Companies include knowledge of issues and technologies for network evolution, identification of services and applications that might generate new revenue streams in a broadband environment, and creation of technologies for critical services integration, call processing, and network management needs. Trends in technology and their impact on the embedded base of network equipment provide insight into strategic planning, business directions, and capital management of the Client Companies.

The work of the project has four principal thrusts: the broadband local exchange experimental prototype, the local distribution network experimental prototype, internetworking and terminal adaptors, and network operations and services management.

The broadband local exchange experimental prototype, Experimental ATM Network Services Environment (EXPANSE), is a hybrid analog/digital experimental testbed emphasizing the use of ATM/SONET-like formats. Issues of call processing, signaling, resource management, and application program interfaces are explored; and research collaborations with vendors will provide multimedia terminal equipment to be used in end-to-end services and applications experiments. The applications will include information broadcasting, multimedia messaging and video on demand.

The local distribution network experimental prototype, H-BUS, is an ATM (Asynchronous Transfer Mode)/SONET (Synchronous Optical Network) LAN (Local Area Network) extending, via optical technologies, the exchange access network interface to user equipments in a local environment. Issues of a standard interface, an efficient media access protocol, and signaling are being explored in the prototype. Methods of utilizing alternative multiplexing techniques for broadcast services are also being explored.

The internetworking research, based in METROCORE technology, investigates issues associated with internetworking gateways such as SMDS (Switched Multimegabit Data Service)/ATM, Ethernet/SMDS, and Fiber Distributed Data Interface (FDDI)/ATM. The issues include routing, signaling, and packet fragmentation and reassembly. Network interfaces to the 800 Megabit/sec High Performance Peripheral Interface (HPPI) bus will also be explored.

The research on network operations and services processing concerns network performance monitoring, access control, operations functions such as service measurement, provision and performance of services

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PROJECT OVERVIEW: (CONT.)

such as packet video, and the applicability of standard operations models.

This is a multi-year project, with interim publications, demonstrations, and experimental designs, and hardware and software elements to be produced throughout the next three years and continuing thereafter if funded.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

This project did not exist until mid-November of 1989. Prior to that, two of the three Districts constituting the present Division existed in other Divisions, and the third District, responsible for the EXPANSE prototype, was drawn from two Districts in still another Division:

LOCAL DISTRIBUTION NETWORKS (previously OPTICAL NETWORK TECHNOLOGIES RESEARCH)

The H-BUS ATM/SONET LAN, optical technologies for local distribution, subcarrier multiplexing, and ATM video interfaces.

BROADBAND INTERNETWORKING RESEARCH (previously METROPOLITAN AREA NETWORK RESEARCH)

The METROCORE network, network services processing and management, services inte- gration in a high-speed network.

BROADBAND SYSTEMS RESEARCH (drawn from MULTIMEDIA COMMUNICATIONS SYSTEMS RESEARCH and INFORMATION NETWORKS RESEARCH)

The EXPANSE exchange access network prototype; research on call processing, network signaling, and network resource allocation.

Important examples of accomplishments are given below:

Broadband Systems Research

o Hardware prototyping work for the EXPANSE experimental testbed included debugging, fabrication, and integration of the timing-generator and interface boards for the EXPANSE cell switch. This included collaboration with District 21493 which made available the Batcher-banyan switch board. The result is an experimental 32x32 switch, with input buffering and output port reservation, 140 Mbit/sec access ports, and 100 Mbit/sec Batcher-banyan internal speed. Another experimental board completed was the cell interface to a microprocessor; the work in second half 1989 included design,

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

debugging, and fabrication of the board, which can support transmission at about 70 Mbits/sec, given a suitably fast processor to drive it. A draft technical memorandum (TM) documenting this cell interface board was completed.

- o Several experimental EXPANSE boards were transferred to Network Technology (Division 27130, H. Rubin, DvM), along with consulting expertise, in support of that Division's planned Switched Multimegabit Data Service (SMDS) demonstration at the March, 1990 Technology Seminar.
- o Work continued on refining a broadband call model, defining the appropriate signaling protocol syntax, and implementing parsing and output modules for the signaling language. These modules are necessary to implementation of the EXPANSE call processing system, and will support multiparty, multimedia services and applications. Work began on defining the software architecture and identifying the software prototyping environment (languages and toolkits) for EXPANSE call processing. Discussions were held with Division 27110 (W. Barr, DvM) to keep that organization, responsible for broadband signaling standards, informed about research in this area.
- o District 21411, Broadband Systems Research, was created and chartered with construction and integration of a Broadband ISDN local exchange laboratory prototype, and interconnections with other division and research prototypes.

Broadband Internetworking Research

- o Demonstrated a three node experimental METROCORE network working at 140 Mbits/sec with packet video, data and packet voice. The packet video can be programmed for different rates (TM-ARH-011316, TM-ARH-013399). A paper was presented at EFOC/LAN 90 (European Fiber Optic Communications/Local Area Network).

- o Transferred the three node experimental METROCORE testbed to one Client Company for their experimentation and to the Software Technology & Systems (ST&S) area of Bellcore (Division 25910, C. Riley, DvM), where it is being used to explore technical questions of service measurement for SMDS billing. The equipment transferred includes experimental LAN service processors (for Ethernet interconnection) and VME (Versa Modul Europe) interfaces (TM-ARH-011316).

- o Transferred a three-node experimental METROCORE testbed to the Naval Research Laboratory under Bellcore's NAVSEA contract. The equipment includes LAN service processors and a 1.7 Gigabit/sec backbone.

- o Demonstrated 280 Mbit/sec access to the METROCORE bus using two parallel 140 Mbit/sec channels. Formulated a modular architecture for a Parallel Media Access Controller, allowing 8 parallel channels at 150 Mbits/sec each to access a 1.2 Gigabits/sec packet

Fig 6

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

data communication system (TM-ARH-014697).

- o Brought up an experimental capability for programming the parameters of the LAN interconnection service processor in the METROCORE experimental testbed. Prototyped presentation layers for the network manager, customer network manager, and user services menu on a multi-window color workstation.

Local Distribution Networks

- o The H-BUS experimental hybrid optical network was studied and reported in TM-ARH-014226 and two published papers. Members of the District investigated protocols for intra-premises traffic and multi-terminal arrangements. Results of the analysis, indicating the size of buffers needed to support intra-premises communication, were documented in TM-ARH-015356. An experimental system was demonstrated for a passive loop architecture using SONET/ATM transport of multiple services to a subscriber interface, and reported in TM-ARH-015168. Completing the H-BUS media access protocol simulation, members of the District incorporated the protocol into an experimental design for a custom Complementary Metal Oxide Semiconductor (CMOS) chip, of about 20,000 transistors, for the media access functions. The chip design includes cell assembly and disassembly, VME interface modules, and media access control functions. The logical and functional aspects of the chip design were tested with computer aided design tools, and the layout for fabrication was completed.

- o Studied call control, signaling, and routing of intra-premises calls for the experimental H-BUS premises network interfaced to BISDN. Results were documented in TM-ARH-015393.

- o Members of the District engaged in system-level studies of the applications of optical amplifiers in multi-wavelength networks. System experiments were performed to examine the crosstalk problems and reported in TM-ARH-013738. Research on system applications of doped-fiber optical amplifiers resulted in a 100 channel experiment reported in TM-ARH-016056.

- o A study of the feasibility of using subcarrier multiplexing techniques for the delivery of multiple channels of broadcast video was reported in TM-ARH-015541. Analog video distribution technologies suitable for loop applications were examined and reported in TM-ARH-015127.

- o A study of the effects on the embedded network of emerging technologies such as fiber optics and VLSI produced adoption scenarios for broadband technology (primarily fiber-in-the-loop) reported in TM-ARH-014929. A study of the effects of new circuit equipment, based on SONET transport standards, was completed and

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

reported in TM-ARH-014325.

- Work in the area of radio alternatives for the local loop was summarized in an article for the Bellcore EXCHANGE magazine and reported in TM-TSY-014935.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as integration of broadband terminal models, multimedia applications, and user interfaces. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this Project.

RESEARCH DIRECTIONS:

Research on an integrated infrastructure for the future intelligent, broadband exchange network, emphasizing experimental prototyping, research collaboration with broadband terminal manufacturers, and research on signaling, call processing and services control.

Research on the integration of services and media in the intelligent, broadband exchange network, emphasizing experimental prototyping and the stressing of network technologies with services and applications invoked by a population of local users.

Research on services processing, adaptors, and gateways for internetworking and Switched Multimegabit Data Service (SMDS) access in an environment including exchange network, metropolitan network, and local network experimental prototypes.

Investigation of network requirements and performance for advanced services such as multimedia messaging, packet video, and video on demand, through prototyping in experimental broadband network testbeds.

Investigation of premises networks and technologies extending the features and interfaces of the broadband exchange network to local equipment and the implication of such networks on the public network.

Research on services coordination and network operations in a multi-network environment, in the context of experimental network testbeds.

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Project Name:
SYSTEMS INTEGRATION

Project No.:
021411

RESEARCH DIRECTIONS: (CONT.)

Investigation of very-high-speed (800 Mbits/sec) subscriber access to broadband networks.

Technology forecasting and impact analysis research.

Project Name: **SYSTEMS INTEGRATION** — Project No.: **021411**

Bellcore Project Manager: **S D PERSONICK** — Tel. No.: **(201) 829-4980**

Bellcore Program Manager: **A. BERGH** — Tel. No.: **(201) 829-4938**

Bellcore Subject Matter Expert: **S B WEINSTEIN** — Tel. No.: **(201) 829-4086**

Bellcore Product Name: **APPLIED RESEARCH**

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/90 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 — Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET   CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

Project Name: LIGHTWAVE SYSTEMS TECHNOLOGY	Project No.: 421301
Bellcore Product Manager: A. BERGH	Tel. No.: (201) 829-4938
This Project is a Component of the Bellcore Product: APPLIED RESEARCH	
Significant Change Date: 08/31/90	

PROJECT OVERVIEW:

The technical areas addressed in this project are intended to enhance the capability and functionality, reduce the costs, and optimize the performance of single-mode lightwave systems which are deployed by the Bellcore Client Companies (BCCs) in their exchange and exchange access networks. Emphasis is being placed on advanced lightwave systems technologies, including wavelength-division multiplexing, coherent transmission, optical amplification and optical signal processing, which will allow more flexible broadband service delivery in conjunction with higher reliability and reduced maintenance ("passive photonic loop"). Also considered are the Synchronous Optical Network/Asynchronous Transfer Mode (SONET/ATM) networking aspects of high-speed transmission systems. The future broadband networks will permit the low-cost provisioning of conventional voice and data services, as well as a variety of new analog and digital video and high-speed data services essential for the healthy growth and long-term economic viability of the BCCs. Applied research performed under this project can be divided into four major areas:

1. High-Speed Lightwave Systems Technologies.

Research in low-noise, high-speed lightwave transmitter/receiver/regenerator technologies is pursued to ensure that the Bellcore Client Companies (BCCs) have access to the most advanced technology at the earliest possible time, can plan the orderly growth and upgrade of future networks, and can provide special services in the multi-gigabit-per-second range in response to growing customer demand. A recent accomplishment was the record transmission experiment at 11 Gbit/sec over a span of 260 km using two optical fiber amplifiers. Our prototype state-of-the-art hybrid multiplexers, receivers, and regeneration circuits contributed to the success of this experiment. We are also exploring advanced integrated and optoelectronic integrated circuit (OEIC) technologies for loop and exchange applications which have the potential for high functionality, small size, low power consumption, high reliability, and low cost. System experiments at the SONET rates of 2.5 and 10 Gbit/sec are being performed to characterize Bellcore's own experimental research prototype OEIC transmitters and receivers and advanced silicon Integrated Circuits (ICs) (using commercial foundry services for the fabrication of the silicon ICs.) We continue inputs into the lightwave transmission standardization process by providing consultation to Bellcore's Technology Systems Area on performance aspects of lightwave

Project Name: LIGHTWAVE SYSTEMS TECHNOLOGY

Project No.: 421301

PROJECT OVERVIEW: (CONT.)

systems, and contributions on SONET and Broadband Network systems standardization in the U.S. T1 Committee and in the International Consultative Committee on Telephone & Telegraph (CCITT). As a noteworthy example, we established a theoretical and experimental foundation for the systems degradations induced by multiple reflections which formed the basis for new standards on reflectances of connectors and splices. This research was recently expanded to include the effects of optical amplifiers, which will be important for future broadband networks. Finally, we are exploring early applications of SONET 2.5 Gbit/sec systems by collaborating with Bellcore's Transwitching Technology Research Division and Carnegie Mellon University to implement a SONET/ATM link between supercomputers for the National Gigabit Network Project. To ensure reliable performance, we are studying 2.5 Gbit/sec SONET/ATM optical transmission and helping to establish advanced research testing capabilities for these systems.

2. Lightwave Technology Applications.

Research is pursued to explore the potential use of innovative lightwave technologies in more functional and cost-effective systems designs which are compatible with the evolving digital broadband network. In particular, we study the performance strength and limitations of both digital and analog systems for the transport of multi-channel video signals in the broadband subscriber loop. We continue to explore the use of optical amplifiers, including both Semiconductor Optical Amplifiers (SOA) and erbium-doped Fiber Optical Amplifiers (FOA), for applications in video distribution to a large number of subscribers. For example, we have demonstrated the first use of an FOA as optical power amplifier for multichannel Amplitude Modulated (AM) television signals distribution. We have also demonstrated, through technology teaming with Network Technology, the first experimental system for the simultaneous transmission of 10 High Definition TV (HDTV) channels over 30 km of single-mode fiber, by using the SCM (Subcarrier-Multiplexing) technique for combining 10 FM (Frequency-Modulated) HDTV channels to modulate a high-bandwidth semiconductor diode laser. We have demonstrated a lightwave system capable of distributing 160 channels of FM television signals, using a combination of OFDM (Optical Frequency-Division-Multiplexing) and SCM: 16 Distributed Feedback (DFB) lasers at different optical frequencies (with 10 GHz frequency spacing) were modulated with 10 FM television signals each, for a total of 160 television channels being transported.

3. Fiber and Interconnect Technologies

Research is pursued in different types of Single-Mode Fibers (SMFs) and fiber-based component technologies, including measuring techniques. This helps to ensure that the BCCs have direct and impartial access to leading-edge knowledge in fiber technology for the

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Project Name:
LIGHTWAVE SYSTEMS TECHNOLOGY

Project No.:
421301

PROJECT OVERVIEW: (CONT.)

planning, procurement, installation, maintenance, and evolutionary use of optical networks. Work in this Division has demonstrated that in cases where optical connectors with low reflectances are required, simple changes in endface polishing techniques achieve the desired performance without requiring major design changes. Together with other Bellcore organizations, we are addressing intermatability and reliability issues associated with optical connectors. In related research, a record 4dB/mW gain efficiency was achieved with an optical fiber amplifier using a unique fiber endface configuration for maximum power coupling to a diode pump laser. The packaging of optical amplifiers for practical applications by the BCCs is also being addressed. Our work provides substantial contributions to standards bodies such as the IEC (International Electrotechnical Commission) and CCITT (International Consultative Committee on Telegraph and Telephone) where members of this Division are active participants in leadership positions.

4. Coherent Multi-Channel Transmission Technologies

Coherent transmission technologies are investigated because of their potential for high receiver sensitivity, high signal channel selectivity and large-channel-count transmission. This technology may eventually enable the BCCs to take full advantage of the enormous information-carrying capability of single mode fiber, once it has advanced to such a degree that its potential economic advantages over direct-detection systems can be determined. Emphasis is placed on multi-channel coherent networks for exchange and subscriber applications, although these same technologies may also prove useful for the routing and switching of signals in future photonic networks. As a noteworthy accomplishment, we recently demonstrated a 16-channel double-star network at the 155 Mbits/sec SONET rate using commercially-supplied distributed-feedback laser packages and prototype rack-mounted terminal equipment. By using doped-fiber amplifiers in this network, we were able to expand the capabilities of the network to simulate the distribution of 16 digital TV signals to more than 10,000 subscribers. We are also moving rapidly to improve this network demonstration to be suitable for field operation and to operate at 622 Mbits/sec for the transmission of high-definition television signals. In another accomplishment aimed at exchange trunk applications, we were able to demonstrate experimental techniques for transmission at the 10 Gbit/sec SONET rate, using either frequency-shift keying or phase-shift keying modulation formats.

Many of the remaining problems yet to be addressed are associated with our emphasis on the practical application of this technology. These involve simple schemes for stabilizing the optical frequency of the transmitter lasers, design of highly-integrated and compact receiver electronics, methods for very fast tuning of the local oscillator lasers to achieve rapid channel acquisition, and studies to establish the practical limits to the technology that may be caused by optical

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Project Name:
LIGHTWAVE SYSTEMS TECHNOLOGY

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421301

PROJECT OVERVIEW: (CONT.)

reflections, fiber four-wave mixing, or other impairments.

5. Technology Impact

The output of our research is being made available to other parts of the Applied Research Area through technical publications, consultation and prototype subsystems; to the requirements and analysis process of Network Technology through consultations and research collaborations, and collaborations in the standards area; to the network architecture planning and standards process of Information Networking Services through active standards participation; to the BCCs directly through consultations and collaborations, licensing agreements, and research collaborations with the telecommunication industry; and to the Telecommunication Community and the World of Science through research collaborations and technical publications. In summary, our research contributions in above areas have been very effective and beneficial to the BCCs and the telecommunications community at large. Our research has strongly influenced introduction strategies for single-mode fiber technologies in the subscriber loop networks of the BCCs, and has influenced the work of other telecommunication organizations and standards bodies.

The following represents a summary of accomplishments performed under Project 421301 from July, 1989 through December, 1989 in support of the optical fiber systems and future broadband loop and exchange networks of the BCCs. Our research for the above reporting period has been described in 23 Journal Papers, 28 Conference Talks, and 15 additional Technical Memoranda. In addition, 1 patent has been issued and 2 patents have been filed during this period.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

Optical Fibers, Interconnection Devices and Passive Components

- Low-Reflectance Connectors
  Multiple reflections between connectors and/or splices may cause degradations in high-speed analog and digital lightwave systems. Reflectances as low as -67dB with 0.43 average insertion loss have been achieved with conventional cylindrical-ferrule connectors through oblique fiber endfaces without requiring design changes. Early applications of low-reflectance connectors could include AM video distribution systems on single-mode fiber.
- Low-Reflectance Variable Optical Attenuator
  Low-reflectance, variable attenuators are important components for testing multi-gigabit-per-second lightwave systems. Prototypes have been successfully built and used for a variety of optical systems experiments. Attenuator reflectances as low as -60 dB could be achieved, which is necessary in systems with optical amplifiers.

Project Name: LIGHTWAVE SYSTEMS TECHNOLOGY
Project No.: 421301

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

- o Optical Minishop
  An Optical Minishop for connecting and joining different types of fibers (including fiber amplifiers), and for terminating and packaging various optical devices, provides important hardware support for systems experiments and technical analysis work within and outside Applied Research.

Standards Activities

- o International Standards Activities
  We continued to participate in leadership positions in both CCITT (International Consultative Committee on Telephone & Telegraph) (P. Kaiser, Coordinator and Spokesman for the US delegation in Study Group XV, Working Party 5, Optical Transmission) and IEC (International Electrotechnical Commission) (W. C. Young, Chairman of Standards Committee 86B, Fiberoptic Interconnection Devices and Passive Components). Several Contributions for CCITT SGXV/WP5 addressed the international standardization of SONET (Question 29/XV) -- whose Recommendation G.957 was approved at the July 1990 Plenary Meeting of SGXV. Another Division 21310 Contribution for Question 18/XV on Local Networks (submitted for information) described the Fiber-to-the-Home trials in the United States.

  As Chairman of IEC SC86B, W. C. Young leads the international standardization of optical connectors, which concentrated on preparing documents for the next Plenary Meeting in October, 1990. He also formed an Advisory Group for planning and managing standards activities related to optical connector reliability, among others.

Optical Amplifiers, Applications and Systems Simulations

- o Fiber Optical Amplifiers (FOA)
  FOAs and Semiconductor Optical Amplifiers (SOAs) are expected to find applications in the loop and exchange plant of the BCCs. In collaboration with the SRI David Sarnoff Lab and the University of Southampton, a high coupling efficiency of 47% was achieved with a record 4dB/mW gain efficiency for a 980 nanometer laser-pumped FOA. A patentability study of this coupling technique is underway.
- o Semiconductor Optical Amplifier (SOA) Performance Limitations in High-Speed Systems
  To better understand the limitations of SOAs, we have performed computer simulations of their performance in high-speed lightwave systems. We found that gain saturation effects in 10 Gibit/sec systems caused eye closure and systems penalties. Consequently, SOAs should be positioned along a fiber link such that the optical signal input power is sufficiently low, i.e., below approximately -20dBm.
- o Fiber Optical Amplifiers (FOA) for Amplitude-Modulated (AM) Video Distribution.
  We have successfully demonstrated the use of an Erbium-doped FOA for the distribution of multi-channel, Amplitude-Modulated,

Project Name: Project No.:
LIGHTWAVE SYSTEMS TECHNOLOGY 421301

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Vestigial-Sideband-Modulation (AM-VSB) television signals. The gain of the FOA was 13dB, and no systems degradations were observed due to nonlinear crosstalk. FOA power amplifiers in such systems could have early practical applications in Fiber-in-the-Loop (FITL) installations.

Video Transport Over Fiber

- *160-FM Channel Broadcast Experiment*
  We have successfully demonstrated the transmission of a record number of 160 FM TV channels to 16 users using a combination of Optical Frequency-Division Multiplexing (OFDM) and Electrical Subcarrier Multiplexing (SCM). An etalon was used both as an optical channel filter and an FM demodulator (i.e., optical frequency discriminator). This is the first demonstration of such a high spectral efficiency of a *one-video-channel* per one GHz Radio Frequency (RF) signal bandwidth.
- 10-Channel *HDTV Transport Over* 30km of Single-Mode Fiber (SMF) Using Subcarrier-Multiplexing
  As part of Technology Teaming with Network Technology (Division 27210, D. Burpee, DVM), we have demonstrated the transmission of 10 HDTV channels over 30km of Single Mode Fiber (SMF) using commercially-available Pulse Frequency Modulated (*PFM*) *transmission* equipment. The 10 HDTV channels were then subcarrier-multiplexed in the 2 to 6 GHz frequency range. An *experimental* system using this technology could be used for the early provisioning of multiple HDTV channels.

High-Speed Lightwave Systems Research

- 2.5 Gbits-per-Second Systems Technology and High-Speed Integrated Circuits (ICs)
  To demonstrate the potential of low-cost implementations of 2.5 Gbit/sec and other next-generation SONET systems, hybrid circuit packages based on high-speed Bellcore/Avantek research prototype ICs were made for systems studies up to SONET STM-64 (i.e., OC-192 or 10 Gbit/sec) signal rates. *There were no* observable degradations resulting from high-speed measurements on the wafer.
- Optoelectronic Integrated Circuits (OEIC) for Gbit/sec Systems
  In collaboration with Lab 211, novel OEIC transmitters comprised of quarter-wavelength-shifted distributed feedback (DFB) lasers and a quaternary Modulation-Doped Field Effect Transistor (MODFET) driver have been employed in 2.5 and 5 Gbit/sec system experiments. We have also tested research prototype rceivers based upon the novel combination of a Metal-Semiconductor-Metal (MSM) photodetector and a MODFET preamplifier, and characterized its performance up to 5 gigaherz.
- High-Speed Direct-Detection Systems with Optical Amplifiers.
  In studying the effect of multiple Rayleigh-scattering on high-speed systems employing optical amplifiers, we determined that Rayleigh scattering can be simply modeled as a "mirror" which acts similarly to discrete reflections in producing multiple reflection

Project Name: LIGHTWAVE SYSTEMS TECHNOLOGY

Project No.: 421301

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

noise. The interferometric noise due to multiple Rayleigh scattering increases with amplifier gain, and restricts the allowable gain to less than about 20 dB for high-speed systems unless optical isolators are employed.

- High-Speed Frequency-Shift Keying (FSK) and Differential-Phase-Shift-Keying (DPSK) Modulation/Direct Detection Transmission Systems.
  We have investigated high-speed direct-detection transmission using both FSK and, for the first time, direct DPSK modulation formats. These techniques represent low-dispersion alternatives to conventional high-speed intensity-modulated systems.
- Optical Signal Processing
  We developed a theory of Distributed Bragg Reflector (DBR) lasers employed as optical filters for use in multiple wavelength optical communication systems. We confirmed our theory by experimental measurements of DBR frequency response and noise properties, in collaboration with Division 21110 (P. W. Smith, DvM). Based on this theory, a new DBR filter structure is proposed which is optimized for multichannel applications.
- Picosecond Pulse Transmission and Dispersion Compensation
  Ultra-short optical pulses may find applications in future very-high-speed lightwave systems (10 Gbits/sec and beyond) and in optical switching. They also facilitate an understanding of the limitations of non-linear pulse transmission in Single-Mode Fibers (SMFs). In collaboration with Division 21110 (P. W. Smith, DvM), a new experimental ultra-short optical pulse generation system has been built. Together with a grating-telescope dispersion compensator, we were able to transmit 500 fsec optical pulses over a 3.2 km long dispersion-shifted SMF.

Multi-Channel Coherent Systems

- 16-Channel Heterodyne Experiment at 622 Megabits/sec.
  We are increasing the capacity of our 16-channel experiment by a factor of four by increasing the modulation speed to 622 Mbits/sec. At present, we have achieved this with only one of the 16 lasers using the Alternate Mark Inversion (AMI) modulation format.
- Packaged Laser Frequency Stability Measurements
  We have measured the absolute optical frequency of a distributed-feedback laser package to vary by less than 300 MHz over a period of more than a month. Periodic checks (once per month or less) may be sufficient to realign the transmitters to account for minor frequency drifts due to laser aging.
- Active Demodulation Circuits
  We have investigated the use of active mixers for use as frequency-shift-keying demodulators because they provide better than 25 dB suppression of intermodulation distortions relative to the signal, even at very low input powers. The active mixers used have sufficient bandwidth to increase the modulation speed from 155 to 622 Mbits/sec, have improved our receiver sensitivity by 7 dB, and have reduced the variation in receiver sensitivity due to

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Project Name: Project No.:
LIGHTWAVE SYSTEMS TECHNOLOGY 421301

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

polarization fluctuations from 3 dB to less than 1 dB.

- Phase-Shift-Keyed (PSK) Homodyne Receiver
  We have demonstrated an Optical Phase-Locked-Loop (OPLL) using miniature Nd:YAG solid state lasers which achieved a phase error as small as two degrees. Using this high performance OPLL, we demonstrated homodyne PSK transmission with a record receiver sensitivity of -62.8 dBm at 140 Mbits/sec (25 photons per bit).

High-Speed Coherent Transmission Systems

- 10 Gigabits/sec Differential Phase-Shift-Keyed (DPSK) Laser Modulation and Reception
  We have demonstrated a satisfactory bipolar drive signal for DPSK modulation at 10 Gbit/sec. Using this modulation signal, we have achieved DPSK transmission using a distributed-feedback laser with 10 MHz linewidth. Work to demonstrate a 10 Gbit/sec heterodyne receiver for this modulation format is in progress.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies and systems. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented form accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Demonstration of the viability of Single-Mode Fiber (SMF), component and systems technologies and concepts, including measurement techniques, through laboatory demonstrations and field experiments (if appropriate, in collaboration with other divisions, and/or with one or more BCCs). Modeling of performance of SMF systems to facilitate analysis of practical systems using standard components, and making simulation tools available to the BCCs.

Theoretical and experimental investigation of advanced SMF transmission characteristics with particular emphasis on loop applications of SMFs. Participation in the standardization of single-mode fibers, SONET (Synchronous Optical Network) systems and fiber-based local broadband systems in the International Consultative Committee on Telephone & Telegraph (CCITT). Studies of fiber-based components, interconnection devices, and optical facility switches, as well as standards leadership in the

Project Name: LIGHTWAVE SYSTEMS TECHNOLOGY
Project No.: 421301

RESEARCH DIRECTIONS: (CONT.)

International Electrotechnical Commission (IEC).

Identification of optical connector reliability issues and participation - together with other Bellcore organizations - in the implementation of reliability evaluation programs leading to future Bellcore requirements and standards positions.

Investigation of SONET/ATM (Asynchronous Transfer Mode) optical transmission and performance issues and participation in establishing standards for the various SONET hierarchy levels, including the future Synchronous Transfer Mode (STM-64) (10 Gbit/sec) rate. Exploration of the early application of prototype STM-16 (2.5 Gbit/sec) equipment as part of a research collaboration with Carnegie Mellon University's Gigabit-per-second Network Project.

Research in systems technologies and applications of High-Density Wavelength-Division-Multiplexing (HD-WDM), based on 10 to 20 high-bandwidth optical channels, including multi-wavelength lasers and laser arrays, detector arrays, WDM devices, fixed and tunable etalon filters, etc., for high-channel-count video distribution in the local network.

Continuation of experimental and theoretical studies of capabilities and limitations of optical amplifiers (both doped-fiber and semi-conductor amplifiers) in high-capacity, multi-channel applications such as in HD-WDM and their impact on optical network and broadband services evolution.

Continue theoretical and experimental investigation of multi-channel heterodyne and homodyne transmission systems, with emphasis on channel assignment, laser frequency stability, laser modulation techniques, local oscillator tuning and channel acquisition, and integration of receiver electronics. The goal is to establish technologies useful for transmission in the range of 155 to 622 Mbit/sec.

Demonstration of a 16-channel coherent double-star network operating at 622 Mbit/sec, with emphasis on establishing practical field operation and understanding the limitations imposed by optical reflections, fiber- and component non-linearities, electronic component bandwidths, and optical amplifiers. Also emphasized will be the integration of the transmitter and receiver opto-electronics to demonstrate the practical feasibility of coherent multichannel distribution.

Together with Lab 211, perform research in Optoelectronic Integrated Circuit (OEIC) technology for loop and exchange applications. Continue study of OEIC transmitters and receivers, as well as more complex optoelectronic integrated circuits with enhanced systems functionality and potential for low-cost loop applications.

Project Name: LIGHTWAVE SYSTEMS TECHNOLOGY

Project No.: 421301

RESEARCH DIRECTIONS: (CONT.)

Exploration of advanced silicon Heterojunction Bi-polar Transistor (HBT) and High-Electron Mobility Transistor (HEMT) integrated circuit technologies for implementation of 2.5 Gbit/sec and high-speed lightwave systems. We have established research collaborations with both Rockwell and Avantek to have access to foundry services and for experimental low-cost, high-speed Large/Very Large Scale Integrated (LSI/VLSI) prototype circuits. This helps to accelerate the introduction of low-cost BISDN in the loop and exchange plant of the Bellcore Client Companies.

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Project Name:
LIGHTWAVE SYSTEMS TECHNOLOGY

Project No.:
421301

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Bellcore Product Name:
APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/84 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET

CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2802
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:
RADIO RESEARCH

Project No.:
421302

Bellcore Product Manager:
A. BERGH

Tel. No.:
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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
08/30/90

PROJECT OVERVIEW:

This project emphasizes applied research on innovative radio technologies and systems that exploit the unique capabilities of radio for providing (1) economical alternative distribution means, and (2) new integrated voice and data services that are highly flexible and portable. A major objective is to provide these new digital radio communications services via small tetherless portable voice handsets and data terminals as a part of local exchange networks. A key component of this work is to investigate integrating the capabilities of radio with the capabilities of the local exchange network infrastructure. Emerging Radio Local Area Networks (RLANs) and their implications on wireless central-office-based packet data access services are a growing area of project interest.

An enormous demand for portable communications has been demonstrated by the widespread popularity of currently available technologies (i.e., cordless telephones) that provide only very limited portable communications. New innovative services to portable handsets and data terminals could be provided as exchange network services by a system using demand-assigned radio links for the last thousand feet or so of local telephone loops. This radio system could provide tetherless portable communications services while making use of integrated operations and billing, network intelligence and future high-speed optical fiber distribution. Such a new portable radio system may enable Regional Companies to offer highly flexible tetherless digital data and voice services that cannot be offered now. Radio is the only means for providing such new innovative integrated portable communications services. Specialized central office based wireless packet data access services could reduce the cost of rearranging data access facilities as customers move.

Advanced digital radio system and radio link architectures, control strategies, techniques and technologies must provide economical, high quality services despite the complex and hostile radio environment around and within buildings. Experimental investigation of radio link techniques in appropriate radio environments is essential to determine technical and economic feasibility.
This project includes applied research on the following topics:

1. Synthesis, computer simulation, and implementation of radio system architectures and control strategies including radio channel access, alerting, active call transfer, and protocols that will mitigate effects of radio propagation and customer

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Project Name: RADIO RESEARCH

Project No.: 421302

PROJECT OVERVIEW: (CONT.)

motion. Comparison of proposed architectures and control techniques in appropriate environments is needed in order to select those providing the best characteristics for exchange network voice and data applications.

2. Synthesis and implementation of innovative radio link digital signal processing, channel coding, speech coding, and privacy techniques that are readily implementable in economical low-power very-large-scale integrated circuits (VLSI). Digital signal processing techniques continue to provide significant improvements in radio link performance in the multipath radio environment, to improve spectrum efficiency by permitting new radio link architectures.
3. Building and testing of laboratory models of radio equipment subassemblies and integration of subassemblies into a laboratory concept prototype system to show experimentally the feasibility of innovative demand-assigned time division multiple access radio link and system control techniques, and to insure that the individual signal processing and control techniques and radio technologies will function as an integrated radio system.
4. Building of experimental radio frequency and baseband subassemblies in advanced low-power hybrid and integrated circuit technologies to insure the feasibility of economical fabrication in large quantities.
5. Field measurements and modeling of radio propagation in appropriate environments within and around buildings. Earlier propagation experiments provided information needed for establishing transmission rates and for inputs to computer simulations of system architecture and control strategies for frequencies around 1 GHz. Further measurements are needed at higher frequencies and in other environments in which low-power portable communication systems and central office based wireless data access systems may be used.
6. Insuring compatible services and network interfaces with digital distribution networks (both fiber and copper), with current switched wireline and wireless networks, and with evolving network intelligence, including participation in the first stages of field experiments using commercially available products.
7. Investigating alternative network infrastructures for providing voice and data services that employ wireless access, including a "high-level" view of the associated economics. To maximize the benefit of this applied research to the Bellcore Client Companies, Technology Transfer and Licensing efforts are beginning to transfer the radio link technology and system architecture and control strategies formulated in this project to the industry.

Applied research will be continued on experimentally verifying new models developed earlier that predict interference in point-to-point microwave radio routes due to scattering from buildings in urban areas. Current interference prediction models used in frequency

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Project Name: Project No.:
RADIO RESEARCH 421302

PROJECT OVERVIEW: (CONT.)

coordination do not adequately take into account the effect of building characteristics and orientation.

In the Bellcore Client Companies, radio has the potential for replacing labor intensive installation and maintenance with large scale integrated electronics. Knowledge of the radio concepts considered in this project is needed for evaluating both new revenue opportunities and bypass potentials.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

During the period of July 1, 1989 to December 31, 1989: a) extensive consultation and review (including a one-year internship for a Division MTS) were provided to Division 27240 (G. R. Ritchie, DvM) for the purpose of preparing a region-specific framework Technical Advisory concerning generic requirements for a portable telecommunications service; b) extensive consultation was provided on radio interference from urban scattering to Division 22370 (F. Zupa, DvM), Division 27240 (G. R. Ritchie, DvM), and Division 82350 (J. N. Norris, DvM) working on improving frequency coordination of point-to-point microwave radio; c) extensive consultation was provided to BCCs on worldwide activity in portable communications and its relationship to exchange networks; d) pooling of knowledge on digital speech coding for digital portable radio occurred with Division 21340 (J. A. Bellisio, DvM); e) extensive consultation was begun with Division 26220 (W. Gifford, DvM) on wireline/wireless network integration; f) information and comments were given to Division 82350 (J. N. Norris, DvM) regarding a National Telecommunications & Information Administration (NTIA) Notice of Inquiry (NOI) on frequency management and petitions (1) by Cellular 21 to hold a trial of British CT-2 technology and (2) by Millicom to initiate experiments leading to a Personal Communications Network. During this period, we wrote 10 technical memoranda, published 2 technical papers, presented 9 talks at technical meetings, conferences, and symposia, were issued one patent, filed 3 patents, wrote 6 other Technical and Engineers Notes and letters, and published a Compendium of papers on Terrestrial Microwave Radio in collaboration with Division 23190 (G. R. Ritchie, DvM).

Portable Digital Radio

- Rapid progress continued toward implementation of an experimental concept prototype of a two-way digital portable radio link. This link uses digital signal processing techniques for demodulation and symbol timing of independent signal bursts. The link now supports two simultaneous portable users with 2 GHz Radio Frequency (RF) circuits to permit on-the-air testing and interfaces to POTS (Plain Old Telephone Service) loops to permit call origination. The 2 GHz RF, intermediate frequency, baseband, speech and POTS loop

Project Name:
RADIO RESEARCH

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

interface processing portions of this link are working in the laboratory. Two experimental "portable" units have been constructed. The portable prototype units incorporate a novel burst modulator coordinated with a switching power RF amplifier which together permit on-the-air rapid burst turn-on/turnoff with no additional adjacent-frequency interference. The electronics for the "fixed" unit have been separated into remote and central-office portions. Completed integration of baseband, Intermediate Frequency (IF) and RF sections of the experimental prototypes to permit on-the-air testing. This included a single receiver selection diversity circuit which provides optimal antenna selection based on signal quality. Performed on-the-air tests of 2 portables on adjacent time slots under near-far conditions. Constructed experimental loop interfaces and integrated them with the central office circuits. Completed the design of experimental electrically-programmable logic devices to show the feasibility of low power operation and integrated these circuits into the portable units. Completed the design of 2 experimental Very Large Scale Integrated (VLSI) chips to perform burst modulation and demodulation. These designs demonstrate the low complexity of novel burst demodulation techniques which are bandwidth efficient. These chip designs were submitted for fabrication in December. Proposed and documented a modulator structure for efficient VLSI implementation (Sollenberger, TM-ARH-015813). Reported results on selection diversity for Time Division Multiple Access (TDMA) portable radio links (Chuang and Sollenberger, Institute of Electrical and Electronics Engineers, Inc. (IEEE) GLOBECOM '89). Reported results on the performance of joint error detection and burst demodulation (Chang and Sollenberger, IEEE GLOBECOM '89).

- o Continued a study of low-complexity adaptive equalization techniques with very low transmission overhead. Such techniques could further mitigate the effects of time delay spread and receiver channel filter imperfections. Demonstrated that a very low-complexity technique using burst storage and "time reversal" that operates on a hard-limited received signal can provide significant performance improvement (Ariyavisitakul, TM-ARH-015241). Extended this "time-reversal" technique to conventional linear equalizers, where even more improvement was obtained.
- o Began further analysis of multipath time delay spread data, collected in offices and an urban area, showing that selection of the radio port with the strongest signal also gave the path with the least time delay spread in most cases. This would minimize the effects of time delay spread in widely-deployed portable communications systems. Began plans for measurements in an urban area at even higher frequencies in collaboration with a Bellcore Client Company. Began a comprehensive attenuation measurement program at four widely-spaced frequencies in office and residential environments.
- o Continued to model spectrum utilization characteristics. (Bernhardt and Chuang, Engineers' Notes, August 4, 1989) In one thrust, time-

Project Name:
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421302

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

slot management (assigning calls to Time-Division Multiplex time slots) was studied by a new simulation (MULTICALL) which simulates thousands of calls spread over hundreds of fixed-radio coverage areas; system occupancy, reuse factor, propagation parameters, etc. were varied for three test algorithms. It was found that one algorithm (saving the best slots for users with low signal) significantly outperformed the others and yielded up to 13 dB improvement (Bernhardt, TM-ARH-015554). A talk on earlier modeling work was also presented (Bernhardt, IEEE GLOBECOM, November 30, 1989). In the other thrust, methods for autonomously determining frequency assignments for fixed radio equipment were studied, along with the use of second-choice routing when traffic blocking occurs. Both of these techniques give significant operational advantages and yield performance improvements as well. The autonomous assignment algorithm yields a stable configuration with only a few iterations. Earlier work was reported (Chuang, TM-ARH-014878, and IEEE GLOBECOM, November 30, 1989). In addition, computer simulation programs were created to analyze the access performance of portable communications systems deployed in groups of multi-story office buildings. This computer model will be used to assess the spectrum requirement in high-use business environments. Early results indicate that variability of wall attenuation characteristics may be the dominant effect.

- Continued work on data throughput estimation for the two-way Rayleigh-fading channel with diversity. Showed how throughput is a function of Carrier/Interference, for various automatic repeat request (ARQ) protocols; one TM was issued (Chang, TM-ARH-014909).
- The basic investigation of data services was also completed; it was concluded that two basic data services are needed: (1) a protected service in which the portable system enhances data integrity via ARQ, and (2) a non-protected service in which the user's end-to-end protocol protects the data integrity (Chang and Porter, TM-ARH-015782, December 9, 1989). Earlier work on synchronization was also reported (Chang and Sollenberger, IEEE GLOBECOM, November 1989).
- Synthesized a configuration for a combined low-noise receiver front end amplifier and antenna diversity switch which offers lower noise, power dissipation, and complexity than conventional approaches (Liu, TM-ARH-015387). The combined amplifier-switch could be implemented in low-complexity integrated form for a digital portable radio. Continued a search for an appropriate integrated-circuit technology to implement a previously documented high-efficiency RF power amplifier (Ariyavisitakul and Liu, IEEE GLOBECOM, November 1989). Continued a survey and experimental study of commercially available low-power RF technology (Krain, Engineer's Notes, August 1989).
- Continued to participate in CCIR (International Radio Consultative Committee) work toward future portable radio telecommunications standards, with attendance at the final meeting of the 1986-90 cycle. Made technical presentations and published papers concerning local exchange applications of digital portable radio

Project Name:
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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

telecommunications to Bellcore Client Company groups, and to outside conferences (Cox, IEEE Communications Magazine, July, 1989, seminar at Virginia Polytechnic Institute, October 1989; Porter, Information Networking Institute at Carnegie Mellon University, December 1989; Arnold, FCC Personal Communications Seminar, July 1989, TIA Microcell Technology Symposium, October 1989, seminar at Columbia University Center for Telecommunications Research, October 1989). Wrote a paper concerning the need for interface standards between cellular systems and the wireline network (Cox et al., TM-ARH-014545, July, 1989).

Point-to-Point Microwave Radio

- Tested on the Bellcore antenna range a second version of an experimental multi-aperture mode-diversity coupler for a standard microwave horn-reflector antenna (see 9F32-11). The analytical procedure was improved to include the effect of several higher order modes. The test results are in good agreement with the design objective. This coupler provides angle diversity protection against multipath fading for existing point-to-point microwave radio systems for both polarizations simultaneously (Noerpel, TM-ARH-014750). A patent has been filed on a diversity-protection system with the multi-aperture coupler. Documentation is being assembled for licensing of the technology.
- Completed an interference-prediction model which incorporates effects of scattering from building structures and thus provides a better estimate of the effect of building orientation than the methods currently used for frequency coordination of microwave radio routes. An experimental setup was completed for a field experiment to verify the directional nature of the reflected interference from building surfaces and to obtain depolarization data. (Noerpel and Ranade, talk at IEEE GLOBECOM'89, November 1989)

Wideband Analog Optical Fiber Distribution

- Continued a study of wideband FM techniques for fiber-optic distribution of multiple RF National Television Standard Code (NTSC) television signals. Completed implementation of a concept prototype demonstrating the technique and employing low-index FM modulation, several modulation index doublers, and simple discriminator detection. Began measurements and investigations aimed at reducing crosstalk distortion levels in the prototype to acceptable levels.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies and systems and communication theory. Emphasis is placed on applications to current and future needs in networks, services and

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Project Name:
RADIO RESEARCH

Project No.:
421302

REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Determine characteristics and parameters for radio propagation in and around buildings. These are required for determining system configurations, limitations on radio links, and suitability of a broad range of frequencies for portable communications systems.

Explore innovative frequency reuse radio system concepts, including system configurations, radio channel access strategies, alerting techniques, and control strategies, for providing new, economical, high quality, spectrally efficient portable communications services.

Explore the effect of wall and floor attenuation on the performance of digital portable radio systems deployed in large multi-storied office buildings.

Further investigate radio link parameters that will provide exchange-network-quality portable communications. These parameters include digital channel rates, frequency channel spacing, privacy methods, digital speech coding approaches, channel coding techniques for error detection, and protocols for data services.

Explore innovative digital radio link architectures, techniques and subassemblies for use in multipath radio environments. This includes investigating and constructing subassemblies, using low-power, very-large-scale integrated or hybrid circuit technologies for radio frequency circuits, radio link control, speech coding, channel coding, data protocols, and privacy.

Expand the capabilities of an initial experimental concept prototype of a digital radio link, using innovative radio link techniques, for providing untethered voice and data communications, including approaches to network integration.

Initiate effort to produce a Technology Transfer and Licensing package incorporating previous applied research on radio link technology and radio system architecture, radio link control and access strategies.

Determine approaches for the integration of portable radio communications into the evolving intelligent network. This includes: (1) identification of the requirements that user mobility places on dynamic network data bases and on transfer of active calls between network switches, and (2) an initial view of overall economic issues.

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RESEARCH DIRECTIONS: (CONT.)

Perform assessment of existing or planned radio systems and technologies for providing personal communications.

Complete the research on diversity techniques for improving the performance of point-to-point digital microwave systems and validate by experimental measurements the new models developed earlier that predict interference due to scattering from buildings.

Determine the performance of hard-limited signalling techniques for fiber optic distribution of multicarrier RF (radio frequency) signals.

Provide technical inputs based on applied research to obtain frequency allocations and to support formulation of national and international standards applicable to portable communications systems.

Provide consulting to Bellcore Client Companies as requested on radio topics, e.g., worldwide activity in portable communications and its relationship to exchange networks, participation in field experiments on portable radio services and radio technology, point-to-point microwave radio, IMTS (Improved Mobile Telephone Service), radio paging, and the use of radio for rural distribution.

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Project Name: RADIO RESEARCH
Project No.: 421302

Bellcore Project Manager: P F LIAO
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Bellcore Program Manager: A. BERGH
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Bellcore Subject Matter Expert: D C COX
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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/84 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:	Project No.
TRANSWITCHING TECHNOLOGY	421303
Bellcore Product Manager:	Tel. No.:
A. BERGH	(201) 829-4938

This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
10/02/90

PROJECT OVERVIEW:

This research supports the Transport Critical Area defined by the Applied Research Advisory Committee, through the pursuit of technologies required for the cost-effective transmission and switching of broadband services. It is the pursuit of technologies that leads to network transport systems where the needs of transmission and switching are studied, and solutions jointly optimized, that gives rise to the project name. There is a great deal of effort in Bellcore, in U.S. Standards bodies, and internationally in the International Consultative Committee on Telephone & Telegraph (CCITT) aimed at formulating standards for a broadband network. Work done on this project in the past has helped to place Bellcore in a leadership position in the definition of this network. The switching and multiplexing concepts advocated for broadband are radically different from those in use in current telecommunications networks in their use of a new packet-like technology called the asynchronous transfer mode (ATM). ATM multiplexing within SONET (the Synchronous Optical Network standards adopted internationally in CCITT) transport systems promises to offer the Bellcore Client Companies (BCCs) a means to deliver a wide variety of new services at low, medium, and high bit rates simultaneously, and in a cost-effective manner.

This project seeks to exploit a number of technological opportunities that will appear in the near future, and will allow our clients to deploy broadband services to a wide base of residential and business subscribers in a cost-effective way. One opportunity is the result of the increasing circuit speed performance of advanced silicon CMOS (Complementary Metal Oxice Semiconductor) and gallium arsenide integrated circuit technologies. The application of such technologies will increase the speed possible with low cost and low power dissipation technologies for broadband subscriber interfaces. These two technologies allow increasing functionality to be included in network interfaces without a substantial cost penalty. Similarly, advances in packaging and interconnection technologies allow high-speed and highly functional integrated circuits to be assembled into compact, reliable interfaces and subsystems. This is important to our clients since it will allow more sophisticated advances in packaging and interconnection technologies allow high-speed and highly functional integrated circuits to be assembled into compact, reliable interfaces and subsystems. This is control and management function capabilities to be implemented in

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Project Name: TRANSWITCHING TECHNOLOGY

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PROJECT OVERVIEW: (CONT.)

hardware, yielding improved performance. An objective of this research is to demonstrate that SONET/ATM interfaces, with all their power for allowing sophisticated network control functions, can be considered for the very cost-sensitive broadband user-network interface. We will work jointly with Bellcore Network Technology to consider candidate functions for the broadband user-network interface, and determine the feasibility, performance and cost impact of these functions. In carefully selected situations, where sufficient detailed knowledge can be gained in no other way, we will participate in the design and fabrication of experimental laboratory prototypes. One example prototype project currently under way is a broadband/advanced television research project jointly supported with Divisions 21340, Video Systems & Signal Processing Research, (J. Bellisio, DvM) and 21370, Network Control Research, (J. Berthold, DvM).

Our pioneering work on broadband circuit switching of several years ago, and our recent work on integrated regeneration functions pointed out the capabilities of CMOS technology. We now pursue one micron sized technologies, (our earlier work was done in two micron sized technologies), to obtain adequate speed margin for the more complex processing functions and higher complexity required for ATM interfaces. Our recent work on SONET multiplexer/framer chips showed the potential for all complex, high-speed (2.5 Gbit/sec) multiplexer functions to be included within a single chip, in a technology capable of low manufacturing cost. We will pursue this line of research, both pushing higher speed and higher functionality, in integrated microelectronics. The result of this work will be to remove the cost penalty of higher system speed. Bellcore Network Technology, Information Networking Services, and the Bellcore Client Companies need to know the ultimate costs to be expected of high-speed digital subscriber access systems as they consider other alternatives for the provision of broadband services, whether switched or broadcast.

A number of Gigabit Network Testbeds have been identified by the Corporation for National Research Initiatives. These testbeds have heavy participation by leading universities, whose participation is Government funded. Bellcore and Bellcore Client Company participation in these projects will encourage the adherence to emerging broadband standards which will be the basis of future BCC Networks. It is expected that research from the Gigabit Network Testbeds will strongly influence the direction of a National Research and Education Network under consideration now by the Government. W. Sincoskie (Division 21490, Computer Networking Research) has been Bellcore's representative in this area. This project will provide support to Sincoskie in the Aurora project, and to Carnegie Mellon University in the Nectar Project, primarily in the area of transport. Our participation in these projects will provide early research prototypes of SONET/ATM access subsystems. Only by providing such early prototypes can we influence the

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PROJECT OVERVIEW: (CONT.)

university participants to adopt SONET/ATM standards, since no such prototypes are currently available from vendors. Adoption of these standards will help to assure that the cost and performance benefits of a uniform system will be available to subscribers by preventing the Balkanization caused by the creation of dissimilar networks.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

There was a great deal of progress in broadband standards in this period. SONET was accepted as a physical layer to support ATM cell transmission, and the basic ATM cell parameters were agreed to in CCITT. We completed the design, fabrication and testing of a CMOS SONET access integrated circuit which supports the transmission of ATM cells within SONET. We also completed the architecture of a 2.488 Gbit/sec SONET multiplexer subsystem that consists of three experimental prototype chip types. The most demanding chip, a 2.488 Gbit/sec multiplexer and demultiplexer, was completed, tested and found to operate satisfactorily to 3 Gbit/sec in initial laboratory testing. The existence of this feasibility demonstration, along with our willingness to make experimental research prototype components available to collaborating universities, resulted in the acceptance of SONET and ATM as the technologies to be used in four out of five testbeds in the Gigabit Network Testbeds planned by the Corporation for National Research Initiatives. An important result came from our explorations of the feasibility of a large ATM switch, a switch with aggregate throughput of one Terabit/sec. A switch architecture was developed which conveniently supports very high speed port rates (1 Gbit/sec or more) and has a compact physical size. An experimental prototype integrated circuit chip which contained an integrated digital signal regenerator was fabricated and tested. It was functional to 250 Mbit/sec, which provides adequate margin to be confident of operation in an application with a speed of 155 Mbit/sec. Such components are critical for eventual application in broadband subscriber loop systems. This project continues to support hardware feasibility, performance, and cost analyses of functions and technological alternatives considered in the broadband user-network interface. Along with other Divisions in Organization 21300, Network Systems, and with collaborators from Bellcore's Network Technology Area, we continue work on a Broadband Transport Prototype project aimed at the simultaneous transmission of a digitally coded and compressed Advanced Television and other signals using ATM within a SONET broadband channel. Our components are planned for incorporation in the Datacycle, DAWN, EXPANSE and Home-bus prototypes of Organization 21400, Network Services Research.

We continued to play an important role in appropriate IEEE standards and professional bodies. We served on the editorial boards of the IEEE Journal on Selected Areas in Communications (JSAC) and the IEEE

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Lightwave Communication Systems Magazine, and as guest editors in three forthcoming JSAC special issues. We were a key player in the formation of an IEEE Technical Committee on Interconnections within High-Speed Digital Systems. We have provided a great deal of expertise and leadership to the IEEE Combus standard activity which seeks to define a SONET-compatible backplane.

Multiplex and Multiaccess Technology:

High-Speed Interface and Multiplexing Circuits for SONET Add/Drop Multiplexer

- The application of high-speed VLSI technology to multiplexing offers the potential of greatly reducing the cost of broadband network access. In the first half of 1990, we completed the testing and experimentation of our prototype SONET STS-48 (2.488 Gbit/sec) interface circuits. The two-chip set is implemented in GaAs technology, and performs the key interface functions for SONET. These include 8:1 multiplexing, 1:8 demultiplexing, byte alignment, and SONET frame detection functions. Our test results indicated that the circuits can operate at data rates up to 2.5 Gbit/sec with a bit error rate less than 1x10E13. In addition, we studied the functional requirements of a SONET STS-3c to STS-48 multiplexer/demultiplexer system. This prototype system is required in our participation in a number of broadband network experiments, including the Gigabit Network Testbeds sponsored by the Defense Advanced Research Project Agency (DARPA) and the National Science Foundation (NSF).

SONET OC-12 Multiplexer/Demultiplexer Test Set

- In the first half of 1990, we constructed an experimental SONET OC-12 multiplexer/demultiplexer test set using our SONET ICs. This test set has been delivered to Division 27220 (L. Scerbo, DvM) for use in their SONET product analysis program. This unit is under heavy utilization in their SONET standard compliance tests of the 622 Mbit/sec vendor equipment.

Broadband Switching Technology:

Large, Synchronous CMOS Switching Chips

- Our research into broadband switching technology concentrates on scalable technology prototyping for high-speed packet switching and SONET crossconnect applications. One goal is the demonstration of a single board 256 x 256 switch interconnection fabric capable of self-routing ATM (Asynchronous Transfer Mode) cells at a rate of 155.52 Mbit/sec. During this period, we optimized the integrated circuit design for both greater noise margin and diagnostics support. The relationship between fabric, interfaces and control functions was analyzed in detail; the results had significant

Project Name:
TRANSWITCHING TECHNOLOGY

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421303

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

impact on the Terabit Switch effort at Bellcore. Our research has demonstrated that today's commodity integrated circuit processes are fully capable of meeting the fabric technology needs in such a terabit switch. We are using this insight to focus attention on the problems of switch monitoring and control in a broadband environment.

Architectures for A Terabit/sec Switch Fabric

o While commodity integrated circuit technologies appear able to support the bit rates required for Terabit/sec ATM switch fabric, a problem that remains as a roadblock to a Terabit/sec switch is the high-speed interconnects needed between integrated circuit elements on different circuit boards and equipment frames. Workers in the Terabit/sec switch project continue to see breakthroughs in interconnect technology. Another path around this roadblock may be architectural solutions that minimize the required interconnects. In this period, we extended work on self-routing crossbar fabrics. The resulting new architectures make maximum use of the component densities expected to be available in the future with Very Large Scale Integrated (VLSI) technology, and require fewer interconnects than other alternatives. Another advantage of this new architecture lies in its ability to easily support port rates much higher than 155 Mbit/sec.

Interconnection and Access Technology:

Optoelectronic Integrated Circuits (OEICs) Subsystems Research

o The goal of this work is to reduce the size and power consumption (and potentially the cost) of the optoelectronic components that would comprise an advanced broadband optical network.

Several advanced prototype laser drivers and 4x4 analog crossbar switches were designed and laid out using the Plessey 0.6 micro-meter bipolar process in the beginning of 1989. The first wafers were delivered in December, 1989. Preliminary testing was performed on individual transistors and on an all NPN (negative-positive-negative) bandgap voltage regulator. The transistors and the voltage regulator were found to operate in a satisfactory manner.

A proposal for a high current efficiency Opto-Electronic Integrated Circuit laser driver was evaluated and reported (TM-ARH-013750, Banwell). This circuit concept is being used in collaboration with Division 21120 (R. Leheny, DvM) to research an experimental monolithic InP Heterostructure Bipolar Transistor (HBT) laser driver.

In collaboration with Division 21110 (P.W. Smith, DvM), we are prototyping an experimental two-dimensional array laser driver to drive the surface emitting lasers recently fabricated at

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421303

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Bellcore. A VLSI integrated circuit for the laser array drivers was designed using a 1.2 micrometer CMOS process. It will drive an 8x8 array of laser diodes at data rates up to 155 Mbit/sec. This important experiment could illustrate new methods for making massive interconnections for subscriber access and intra-machine interconnections. It could open up new switching and subscriber access architectures. We plan to receive the completed ICs from the foundry in the fourth quarter of 1990.

Simplified Laser-Fiber Coupling Technique

- We completed a proof-of-concept demonstration of a new method for coupling lasers to single-mode fibers at room temperature, using an electroplating technique. Using a simple butt-coupling approach, we achieved coupling efficiency as high as 14%; and further investigation indicates that we could achieve much higher efficiency using lensed fibers. We expect to file a patent on this technique during the second half of 1990. This method holds the potential for reducing the cost of optical transmitters, since it greatly simplifies the fiber-to-laser alignment process.

IEEE Combus Standard Activities

- We continue to play a major role in the formulation of the Combus (IEEE P1396) standard for a SONET-compatible packplane. Our contributions include heading the subcommittee writing the mechanical/physical specification, developing criteria for selection of a backplane connector, and coordinating the organization of the documentation. We also initiated a backplane prototyping activity to characterize the electrical performance of the backplane and to examine various architecture and logic issues. We designed an experimental prototype of the backplane and ordered many of the required parts. We began to involve other Bellcore organizations in this activity, e.g., Division 27510 (D. Shelton, DvM) in the area of connector reliability.

Cable Tracking:

Cable Tracking

- A novel method for tracking buried all dielectric cables in lightning prone areas was proposed and tested in the laboratory. An experiment was performed at Bellcore's outdoor Chester site, and the results agreed with our theoretical predications (TM-ARH-014138, Banwell).

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies. Emphasis is placed on applications to current and

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Project Name:
TRANSWITCHING TECHNOLOGY

Project No.:
421303

REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Explore key technology areas in broadband access, multiplexing and switching. Advance technologies necessary to allow cost effective subscriber access, with an emphasis on high-speed, very large scale integration (VLSI) digital circuits.

Research on technology issues associated with fiber-based SONET/ATM networks. Provide technology foundation for Bellcore work projects on broadband standards, requirements and product analysis.

Fabricate experimental prototype systems and subsystems for use in (a) Bellcore Network Technology Area product analysis (for example, SONET test sets); (b) Bellcore testbeds in broadband and INA networks (for example, advanced television transport); (c) Gigabit Network Testbeds with Bellcore and BCC participation.

Research on high-speed optical and electrical interconnection technologies which are critical to the implementation of future broadband transmission and switching systems. This will also include SONET-compatible backplanes to support the IEEE Combus standards.

Project Name: TRANSWITCHING TECHNOLOGY
Project No.: 421303

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Bellcore Subject Matter Expert: N. K. CHEUNG
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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/84 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01
Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR -TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name: VIDEO SYSTEMS TECHNOLOGY	Project No.: 421306
Bellcore Product Manager: A. BERGH	Tel. No.: (201) 829-4938
This Project is a Component of the Bellcore Product: APPLIED RESEARCH	
Significant Change Date: 10/01/90	

PROJECT OVERVIEW:

Telecommunications systems become useful only when there is a good coupling between network capabilities and the needs of information-based services. Signal processing is the enabling technology for matching network transport capabilities to service-driven needs. This project emphasizes several specific areas of signal processing research. High definition television (HDTV) and digital optical fiber are two emerging technologies which could form ideal complements for new image-based communications services. Research to realize this promise addresses all of the key end-to-end technical issues that might arise if a Bellcore Client Company (BCC) broadband digital fiber system was used to transport HDTV. In another research initiative, the technologies needed for the transport of video signals on existing wire pairs are explored. Here, the research follows two directions: the digital compression of television signals to low bit rates; and the signal processing technology needed to operate existing subscriber lines at significantly higher bit rates than is now possible. In yet another dimension of signal processing, research into implementable neural networks may lead to practical solutions to problems of pattern recognition and artificial intelligence which are difficult to solve using conventionally programmed computers.

In order to perform this research, we need to be expert in image coding theory, computer simulation, high-speed digital processing, very large scale integrated (VLSI) circuit technology, computer aided design (CAD) and the associated areas of network transport protocols and control. Work typically results in technology ready to be integrated into Bellcore's overall system plans and in advocacy of standards positions. To do this work in a credible and expeditious way, we frequently need to build experimental research prototypes which often contain unique VLSI circuits. The construction of research prototypes and the assembly of the necessary CAD environment to facilitate this work are, therefore, necessary components of the research process. The VLSI methodology developed in this project is also extensively used elsewhere in Bellcore Applied Research, and our VLSI implementation experiments improve our technology transfer opportunities.

High Definition Television for Broadband Networks

Research on Advanced Television (ATV) has been an ongoing effort in this project from its inception. Consequently, we are very well

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PROJECT OVERVIEW: (CONT.)

positioned in this area now that interest in HDTV, the highest quality form of ATV thus far defined, is peaking. Much research in the U.S. is focused on methods for the analog transmission of ATV via the airwaves. We, however, anticipate that the evolution of the exchange network into a digital fiber optic system will offer an unparalled opportunity to provide an economical, high quality, robust and flexible transport system for ATV services. We have extensively researched, using computer simulation, algorithms for the compression of HDTV into the proposed SONET (Synchronous Optical Network)/ Broadband Network 155 Mbit/sec channel (gross rate). We are confident of our theoretical results, but at least two key research questions remain: the picture quality under actual conditions, and the practical feasiblity of the all-digital fiber approach with respect to more near-term, less capable alternatives. Construction of a research prototype is the most straightforward, reliable, and cost-effective way of resolving these issues. Work, therefore, is continuing on a Broadband Network/HDTV research prototype system that will demonstrate the transport of HDTV on a single SONET STS-3c (Synchronous Transmission Signal at 3rd Level Hierarchy) channel. The work builds on video compression and Broadband Network standards research that has been ongoing. The research will be generically applicable to a wide range of ATV standards and broadband distribution architectures including point-to-point, broadband/bus and multi-wavelength lightwave-based networks.

Simulation work has been concluded. The resulting algorithm produces high quality images, is robust, and permits relatively low complexity realization. Detailed analytical work on the architecture and the creation of VLSI parts for a research prototype are continuing.

Concurrently with this research, we prepared and presented a highly successful technical seminar (March 19-20, 1990) with extensive supporting documentation to advise others of our findings. A second such technical seminar will take place on October 16-17, 1990. In this way, those interested in planning and developing ATV transport systems for the BCCs, based on our technology, will have early access to the information. These seminars help achieve our objective of efficiently and rapidly transferring our research results to other laboratories so they can start building on our ideas.

In addition to the HDTV system research described above, we are also exploring ATV technology for specialized applications which would make even greater use of the packet-transport attributes of the proposed Broadband Networks. Such a system, now in the simulation state, would allow customers the option of balancing quality against transport cost to optimize performance for services ranging from teleconferencing to medical imaging.

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ISDN (Integrated Services Digital Network) Video

With about 1000:1 digital bandwidth compresssion, motion video can be transmitted through the ISDN Basic Access ("B") channels. Feasibility has already been demonstrated with some proprietary video coding equipment. However, major business opportunities for the BCCs may emerge only when the picture quality is improved, the algorithms are standardized, and the coder/decoder (codec) complexity can be reduced. We have already devised and patented new algorithms with the potential of quality superior to existing codecs. Some of our algorithms have now been adopted in international standards. Bellcore has also demonstrated that some key functional blocks with a codec can be efficiently implemented using VLSI. With the large market potential of ISDN, a low-cost acceptable-quality video conference system now seems feasible with today's technology. Researchers around the world recognize this fact and are working intensely on this subject. Many vendors, however, are holding their coding expertise proprietary and are not expected to make it available to standards bodies. CCITT (International Consultative Committee on Telephone & Telegraph), an international standards organization, has recently (with our participation) approved a draft recommendation on video coding for ISDN. Research effort has now been shifted towards stimulation of the VLSI implementation of such a codec for service demonstrations.

The successful introduction of a new video conference service would not only generate revenues for the BCCs, but may also stimulate the desire for new Broadband Network services in the future. The ISDN-rate "videophone" will help preserve some of the value of the existing copper-based plant during the period that new optical fibers are being extended directly to customers by allowing both sets of customers to intercommunicate via ISDN/videophone.

Because of the significant effort required for the proposed work, much of the research is done under research collaboration agreements. This gives us considerable leverage with respect to the construction of research prototypes in support of CCITT standards activities as well as BCC field experiments.

High-Bit-Rate Digital Subscriber Lines and Asymmetrical Digital Subscriber Lines

Although optical fiber may dominate loop transmission in the future, high-speed digital services are already emerging, and a near-term solution is needed until fiber access is widely available. Fortunately, recent advances in digital signal processing and VLSI technology may make the transmission of digital data over nonloaded subscriber loops at bit rates significantly above the ISDN Basic Access rate feasible. In particular, our research has focused on High-Bit-Rate Digital Subscriber Lines (HDSL) and Asymmetric Digital Subscriber Lines (ADSL) signal processing techniques. HDSL is a

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scheme that uses two pairs for providing repeaterless DS-1 rate (1.544 Mbit/sec, full duplex) capability in the Carrier Serving Area (CSA) up to 12 kft with no pair selection required. ADSL is a scheme that uses one pair to provide DS-1 rate transport in one direction above a standard telephone (or possibly ISDN Basic Access) channel over 18 kft loop length.

Both HDSL and ADSL schemes build on our knowledge of the characteristics of existing loop plant, and upon rapidly advancing technologies in both signal processing algorithms and VLSI implementations. Our research program is now concentrating on HDSL, with ADSL as a new thrust. HDSL research includes adaptive wire-pair equalization, adaptive echo cancellation, line coding, timing recovery, and research prototyping. A near-term result is expected to be information to support repeaterless DS-1 Service up to 12 kft over existing metallic loops. This effort is a natural follow-up to our very successful efforts on ISDN Digital Subscriber Lines. For ADSL, we anticipate that recent dramatic advances in video compression could present a new service opportunity for the BCCs. In addition to the video opportunity, the ADSL could be important for high-speed communciations services.

Very Large Scale Integrated Circuit Experiments

It is mistakenly thought by some that VLSI implementation is useful only as the last step before volume production. Experimental VLSI, is, in fact, a central part of signal processing research for two basic reasons: many high bit-rate functions can only be demonstrated by using circuitry with the microscopic dimensions and consequent high frequency performance of VLSI; and the usefulness of a resarch prototype is often apparent only when it has been shown that certain immensely difficult computations and signal processing functions are reducible to a potentially low-cost microcircuit. As part of the proof-of-concept, which is an intimate part of this project, we construct experimental VLSI, using commercial computer aids where applicable, or tools of our own design when these address our unique needs better.

Computer-aided design (CAD) tools for experimental integrated circuits continue to be improved. Research on CAD for VLSI at the symbolic system level results in specialized tools that can achieve high performance and quick turnaround in designing the VLSI experimental research prototypes needed for numerous network systems and service experiments. There is a large base of customers across Applied Research who continue to depend on these tools, and we use these tools ourselves to create experimental circuits needed for video coding, neural network research and other network technology demonstrations. New, more powerful tools have been prepared for release to the Bellcore user community, and they play an important role in the timely creation of the experimental integrated circuits for the ATV project.

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Neural Network Research

The long term goal for neural network research is to solve problems in pattern recognition and artificial intelligence that are easy for humans but difficult when using conventional computer based techniques. Within neural sytems, knowledge is encoded by training rather than by programming so that powerful learning algorithms for neural style networks are needed. We believe, that to be useful, algorithms must be implementable in parallel hardware because training takes too long using serial computer simulations. Therefore, the algorithms should take into account the constraints imposed by VLSI. We propose to extend our study of electronic implementation issues to large scale systems using the following approaches: 1) further research on learning algorithms and architectures suitable for modular VLSI implementation; 2) functional simulation of large scale hardware systems using benchmark test problems; 3) creation of prototype chips suitable for inclusion in such sustems; 4) experimental prototypes of board-level electronic systems using neural network chips; and, 5) telecommunications applications demonstrations using the hardware and software we create.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

The efficient technology transfer of research concepts to standard applications is an activity shared between the Applied Research Area and the other parts of Bellcore. As research projects reach maturity, ideas generated must be evaluated, filtered, and integrated into a coherent standards position. The effectiveness of the advocacy of these positions (both nationally and internationally) is enhanced if the original investigators participate in the standards process. A great deal of our researchers' time and effort is dedicated to making this type of technology transfer work smoothly.

Because of our internally developed knowledge base, we are key participants in the FCC Systems Sub-Committee studying ATV, have a major impact on North American plans for Broadband Networks, and are CCITT Specialists on low-bit rate video. Our CAD is an internal deliverable used in Bellcore Applied Research. Our seminar and and documentation on Advanced Television for Broadband/ISDN helped disseminate research results to the world at large. As a research by-product, certain VLSI chips are licensable. During the first half of 1990, we published 27 papers externally, presented 27 talks at technical meetings and conferences, filed two U.S. patents and were granted one patent.

Coding Algorithms for Digital Transmission of ATV
o Computer studies of algorithms for compressing very high quality

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

video signals with virtually imperceptible visual degradation have continued. The prime aim of these studies was to achieve the compression of HDTV (High Definition TV to the roughly 130 Mbit/sec net payload of the proposed SONET/Broadband STS-3c channel. HDTV has roughly doubled the horizontal and vertical resolution of the current 525 line display standard, and uncompressed HDTV requires 800 to 1200 Mbit/sec. Thus, compression in the range of 6:1 to 9:1 is required. Some emphasis is also placed on "embedded" or "layered" compression, where a separable portion of the compressed HDTV signal is used to represent an embedded EDTV (Enhanced Definition TV, another classification within ADTV) signal; i.e., an image substantially better than ordinary TV. The additional bits in the signal then serve to improve the resolution to full HDTV quality. The compression algorithms studied are carefully chosen so that they can take full advantage of the economies of VLSI circuit realizations. After a thorough investigation of several compression algorithms, we have chosen and continue to refine one that produces excellent visual quality, is robust, and requires minimal complexity for implementation. We are also continuing to obtain and upgrade the highly specialized storage display and computer equipment required for the full analysis and evaluation of the image quality resulting from our compression simulations.

High-Bit Rate Digital Subscriber Lines and Asymmetrical Digital Subscriber Lines

- In collaboration with Divisions 21240 (J. McKenna, DvM) and 23310 (R. Laane, DvM), we explored digital signal processing (DSP) techniques for the High-Bit-Rate Digital Subscriber Lines (HDSL) using the embedded base of copper loop plant. Our research effort included theoretical analyses and the selective prototyping of high-speed electronics to explore the feasibility of transmitting in both directions at 1.544 Mbit/sec through metallic loops without any repeaters, pair selection, or conditioning. Many critical issues including timing recovery, echo cancellation, line coding and equalization, and crosstalk cancellation were proposed, analyzed and demonstrated for this application.

  Based on our patented timing recovery method, a commercially available DSP chip, and a decision feedback equalizer prototyping system, we have demonstrated a high-speed timing recovery technique. In collaboration with Division 23310 (R. Laane, DvM), we have jointly prototyped a real-time linear echo canceler operating at the 1.544 Mbit/sec rate for the HDSL application. Both the timing recovery system and the real-time linear echo canceler were demonstrated successfully at the Bellcore Technology Seminar in Del Lago, Texas, in March, 1990. In order to relieve the stringent requirement for timing recovery, we are now investigating and implementing another HDSL receiver with a decision feedback equalizer (DFE) and fractionally-spaced

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

equalizer (FSE) as part of its architecture. System and circuit level work has been completed. The preliminary analysis of an FSE-based HDSL receiver was completed and documented. A pseudo real-time DSP implementation of a 21-tap FSE and 40-tap DFE which can train itself to adjust for wire-pair variations is now working. The design of an enhanced version of a quasi-real time, DSP-based loop emulator to evaluate our FSE-based HDSL receiver was completed.

Our research effort had previously concentrated on HDSL, and Asymmetrical DSL (ADSL) is now a new thrust. A preliminary analysis of baseband multilevel transmission schemes for the ADSL was completed and documented. As a means of stimulating early industry involvement, and of combining our research efforts on HDSL with ideas generated from industry, universities and vendors, we organized an IEEE-sponsored HDSL Workshop which was held in New Jersey this March. We are in the process of preparing a Research Compendium on High-Bit-Rate Digital Transport Technology for the Copper Loop. (This work was performed under Project 621306).

Study of Learning Algorithms for Neural Networks

- o Unlike conventional computers, neural network computers have the the property of coding information by learning rather than by programming. We have shown that our learning algorithm using noise leads to stable final states, even if the connections in the neural network are not the same strength in both directions. We have investigated a deterministic version of our algorithm which is more computationally efficient and may have advantages for temporal sequence learning, since stochastic averages over time are not involved. We have studied the scaling properties of these algorithms as the problem size is increased to the level needed for real-world problems. (This work was performed under Project 621307).

X-windows Based Graphical Simulator for Neural Network Learning

- o A graphical software simulator was written which displays the state of the neural network as it learns. By using X-windows and a modular software style, the simulations can be run remotely on a fast computer while being displayed locally. This serves as a tool to test learning algorithms, incorporate hardware constraints, study applications, and, in the future, serve as a graphical front end for testing neural network chips and hardware systems. (This work was performed under Project 621307).

Low Bit-Rate Video Standardization

- o We continued to support the standardization of a video coding algorithm at 64 Kbit/sec (kilobits/second) and multiples of 64 Kbit/sec to 2 Mbit/sec sponsored by the CCITT Study Group XV Working Party XV/1. CCITT approved the final version of the

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

recommendation in July, 1990. In collaboration with AT&T Bell Labs PictureTel, and VideoTelecom, flexible hardware experiments of video codecs based on CCITT proposals were completed and tested for compatibility. These codecs have been successfully connected through and ISDN switch in Red Bank, NJ, early this year.

VLSI Experiments for Low Bit-Rate Video

- o In a research collaboration with Graphics Communications Technologies (GCT), layouts of three experimental VLSI chips and logic design of a fourth chip for low bit-rate video were completed. The first chip incorporates an 8x8 two-dimensional Discrete Cosine Transform (DCT) and Inverse DCT (IDCT) processor with input/output scan converters. The second is a flexible full search block-matching motion estimation processor. The third and fourth are a programmable variable-word length coder and decoder, respectively. All four chips represent key technologies necessary for future ubiquitous video services, and are useful as benchmarks in understanding the performance/ complexity tradeoffs needed to drive the standards process.

High-Speed CMOS (Complementary Metal Oxide Semiconductor) Feasibility Studies

- o Feasibility studies were begun for very-high-speed experimental integrated circuits using the commercially available "CMOS" integrated circuit technology for use in SONET interfaces and laser drivers at the 622 Mbit/sec SONET (STS-12) rate, and to investigate the possible application of low-cost, high density CMOS technology to areas where more expensive Gallium Arsenide integrated circuit technology might have to be employed otherwise. A test chip using a 1.2 micron CMOS process and incorporating important functions that will aid in demonstrating high-speed capabilities was fabricated and tested. Synchronous functions of a logical complexity similar to that required to build multiplexers were demonstrted at a speed of 688 MHz. In a second test chip, also in a 1.2 micron CMOS process, we are experimenting with clock recovery and data regeneration at 622 MHz. This chip will provide a calibration on some of the potential difficulties of providing high-bit rate access to residential customers with low-cost technology.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies and systems and information age service capabilities. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this

Project Name:
VIDEO SYSTEMS TECHNOLOGY

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REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Research will continue on the experimental prototype system that will demonstrate the compression and digital transmission of High Definition TV in the proposed Broadband Network environment. A particular focus of this research will be to choose algorithms that will provide maximal compatibility with the over-the-air broadcast ATV standard that will be chosen under FCC auspices. We will also continue our strong interaction with standards organizations on issues related to the digital transmission of video.

We will continue to conduct research on a broad range of video compression algorithms, hardware architectures, and systems for video based services of all kinds.

We expect to provide visual telephony through an ISDN switch using video codecs based on the proposed CCITT specifications. We will also continue work on VLSI experiments of several key signal processing modules in the low bit-rate video codec to demonstrate the feasibility of widespread affordable video services.

We will investigate the benefits of using statistically variable packet transmission for ATV. Other significant research issues that will be addressed include the difficult problem of interfacing the variable bit rate video generated with the transmission channel, the error detection and mitigation problem at the receiver, as well as video timing and synchronization recovery at the receiver.

Research will continue on the engineering, layout, and fabrication of the experimental VLSI chips required to implement the BISDN/SONET HDTV research prototype system. These chips will efficiently realize critical functions and will lead to a demonstration of the transport of HDTV on a single STS-3C (synchronous transmission signal at third level hierarchy) 155 Mbit/sec channel. This work builds on video compression and Broadband Network standards research that has been ongoing. This work is being done in collaboration with Division 21330 (N. Cheung, DvM).

We will continue the integration of Bellcore VLSI CAD (Computer Aided Design) tools with other available tools, as appropriate, with particular emphasis on providing a CAD environment that is best matched to increased research productivity, circuit speed and circuit density for specific research projects in our applied research. Extensions of the tools to higher levels of automation

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RESEARCH DIRECTIONS: (CONT.)

and to technologies beyond digital CMOS (Complementary Metal Oxide Semiconductor) will also be pursued.

Research will continue on algorithms for learning in modular neural networks. We will perform simulations of these algorithms using extensions of our modular simulator on test problems. We will build a cascadable neural network learning chip that incorporates lessons from the study of learning algorithms and can form a multi-chip system. We expect to create a board-level system experiment using available chips or those to be created in order to demonstrate the power of a parallel electronic implementation. We will explore practical application of an electronic neural network system in image or speech processing or real-time network control.

Research will continue in the application of digital signal processing techniques and VLSI technology to increase the transmission capabilities of the copper loop plant. Significant efforts, both HDSL and ADSL, are now focused on demonstrating the feasibility of high bit-rate digital transport technology that can support repeaterless DS-1 rate services in the loop and drop connections for fiber-to-the-curb.

We will continue to team with other Bellcore areas to implement and demonstrate a new HDSL transceiver and necessary signal processing techniques for HDSL applications.

Research will continue on the application of low-cost CMOS VLSI at very high speeds, with emphasis on BISDN and optical interconnect functions.

We will continue to conduct research in selected areas of digital signal processing for telecommunications applications. These include system studies, algorithm research, simulation, VLSI architectures, real-time implementation, and research prototyping. Specific topics would depend on the need, impact, and degree of challenge.

Project Name: VIDEO SYSTEMS TECHNOLOGY
Project No.: 421306

Bellcore Project Manager: P F LIAO
Tel. No.: (908) 758-3100

Bellcore Program Manager: A. BERGH
Tel. No.: (201) 829-4938

Bellcore Subject Matter Expert: J A BELLISIO
Tel. No.: (908) 758-2959

Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/84 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name: SYSTEMS PRINCIPLES
Project No.: 621204

Bellcore Product Manager: A. BERGH
Tel. No.: (201) 829-4938

This Project is a Component of the Bellcore Product: APPLIED RESEARCH

Significant Change Date: 08/14/90

PROJECT OVERVIEW:

Systems Principles Research is involved in work aimed at increasing our understanding of, and our ability to explore design principles for systems of importance to the telephone business. Some of this work is focused on enhancing the utility of the existing network in order to provide new revenue opportunities. An example of this is the continuing work on the High-Speed Digital Subscriber Loop project. Other work is focused on understanding new systems with revenue potential such as our performance analysis of packet switched network architectures and our studies of optical communication network architectures. Still other work is aimed at providing more cost effective ways of pursuing the telecommunications business. For example, because we believe that parallel processing computers will be most cost effective for many applications in the telephone business, we have an effort in exploring new uses for parallel computing.

During the 6 month period under review, members of Division 21240 performed research on a wide variety of topics which can be roughly divided into 7 categories.

1. We continued to work on improving both the performance and our understanding of the L.0 programming language. This included joint work with Division 25930 (P. Deering, DvM) in adding new features to the language, and fundamental studies on the relation between L.0 and temporal logic. An L.0 compiler for the Y machine was written, and we continued to investigate the use of the Y machine as a fast switch.
2. We expanded our research effort in parallel processing.
3. We continued our research on the mathematical foundations of learning theory.
4. We continued to work on communication theory. Of particular importance is the work done on the High-speed Digital Subscriber Loop project. In addition, we have conducted research in optical communication and data compression.
5. We have concluded work on aids for use of the telephone network by the handicapped and disabled. We continue as consultants in this area.
6. We have continued our research on probabilistic modeling, including the performance analysis of packet switched networks and information technologies, and we have continued to do fundamental research on stochastic processes.
7. We have begun to construct experimental research prototypes of

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PROJECT OVERVIEW: (CONT.)

Neural Network Research

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

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o Unlike conventional computers, neural network computers have the the property of coding information by learning rather than by programming. We have shown that our learning algorithm using noise leads to stable final states, even if the connections in the neural network are not the same strength in both directions. We have investigated a deterministic version of our algorithm which is more computationally efficient and may have advantages for temporal sequence learning, since stochastic averages over time are not involved. We have studied the scaling properties of these algorithms as the problem size is increased to the level needed for real-world problems. (This work was performed under Project 621307).

X-windows Based Graphical Simulator for Neural Network Learning

o A graphical software simulator was written which displays the state of the neural network as it learns. By using X-windows and a modular software style, the simulations can be run remotely on a fast computer while being displayed locally. This serves as a tool to test learning algorithms, incorporate hardware constraints, study applications, and, in the future, serve as a graphical front end for testing neural network chips and hardware systems. (This work was performed under Project 621307).

Low Bit-Rate Video Standardization

o We continued to support the standardization of a video coding algorithm at 64 Kbit/sec (kilobits/second) and multiples of 64 Kbit/sec to 2 Mbit/sec sponsored by the CCITT Study Group XV Working Party XV/1. CCITT approved the final version of the

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Project Name:
VIDEO SYSTEMS TECHNOLOGY

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421306

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

recommendation in July, 1990. In collaboration with AT&T Bell Labs PictureTel, and VideoTelecom, flexible hardware experiments of video codecs based on CCITT proposals were completed and tested for compatibility. These codecs have been successfully connected through and ISDN switch in Red Bank, NJ, early this year.

VLSI Experiments for Low Bit-Rate Video

o In a research collaboration with Graphics Communications Technologies (GCT), layouts of three experimental VLSI chips and logic design of a fourth chip for low bit-rate video were completed. The first chip incorporates an 8x8 two-dimensional Discrete Cosine Transform (DCT) and Inverse DCT (IDCT) processor with input/output scan converters. The second is a flexible full search block-matching motion estimation processor. The third and fourth are a programmable variable-word length coder and decoder, respectively. All four chips represent key technologies necessary for future ubiquitous video services, and are useful as benchmarks in understanding the performance/ complexity tradeoffs needed to drive the standards process.

High-Speed CMOS (Complementary Metal Oxide Semiconductor) Feasibility Studies

o Feasibility studies were begun for very-high-speed experimental integrated circuits using the commercially available "CMOS" integrated circuit technology for use in SONET interfaces and laser drivers at the 622 Mbit/sec SONET (STS-12) rate, and to investigate the possible application of low-cost, high density CMOS technology to areas where more expensive Gallium Arsenide integrated circuit technology might have to be employed otherwise. A test chip using a 1.2 micron CMOS process and incorporating important functions that will aid in demonstrating high-speed capabilities was fabricated and tested. Synchronous functions of a logical complexity similar to that required to build multiplexers were demonstrted at a speed of 688 MHz. In a second test chip, also in a 1.2 micron CMOS process, we are experimenting with clock recovery and data regeneration at 622 MHz. This chip will provide a calibration on some of the potential difficulties of providing high-bit rate access to residential customers with low-cost technology.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies and systems and information age service capabilities. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this

Project Name:
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REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Research will continue on the experimental prototype system that will demonstrate the compression and digital transmission of High Definition TV in the proposed Broadband Network environment. A particular focus of this research will be to choose algorithms that will provide maximal compatibility with the over-the-air broadcast ATV standard that will be chosen under FCC auspices. We will also continue our strong interaction with standards organizations on issues related to the digital transmission of video.

We will continue to conduct research on a broad range of video compression algorithms, hardware architectures, and systems for video based services of all kinds.

We expect to provide visual telephony through an ISDN switch using video codecs based on the proposed CCITT specifications. We will also continue work on VLSI experiments of several key signal processing modules in the low bit-rate video codec to demonstrate the feasibility of widespread affordable video services.

We will investigate the benefits of using statistically variable packet transmission for ATV. Other significant research issues that will be addressed include the difficult problem of interfacing the variable bit rate video generated with the transmission channel, the error detection and mitigation problem at the receiver, as well as video timing and synchronization recovery at the receiver.

Research will continue on the engineering, layout, and fabrication of the experimental VLSI chips required to implement the BISDN/SONET HDTV research prototype system. These chips will efficiently realize critical functions and will lead to a demonstration of the transport of HDTV on a single STS-3C (synchronous transmission signal at third level hierarchy) 155 Mbit/sec channel. This work builds on video compression and Broadband Network standards research that has been ongoing. This work is being done in collaboration with Division 21330 (N. Cheung, DvM).

We will continue the integration of Bellcore VLSI CAD (Computer Aided Design) tools with other available tools, as appropriate, with particular emphasis on providing a CAD environment that is best matched to increased research productivity, circuit speed and circuit density for specific research projects in our applied research. Extensions of the tools to higher levels of automation

Project Name: VIDEO SYSTEMS TECHNOLOGY

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RESEARCH DIRECTIONS: (CONT.)

and to technologies beyond digital CMOS (Complementary Metal Oxide Semiconductor) will also be pursued.

Research will continue on algorithms for learning in modular neural networks. We will perform simulations of these algorithms using extensions of our modular simulator on test problems. We will build a cascadable neural network learning chip that incorporates lessons from the study of learning algorithms and can form a multi-chip system. We expect to create a board-level system experiment using available chips or those to be created in order to demonstrate the power of a parallel electronic implementation. We will explore practical application of an electronic neural network system in image or speech processing or real-time network control.

Research will continue in the application of digital signal processing techniques and VLSI technology to increase the transmission capabilities of the copper loop plant. Significant efforts, both HDSL and ADSL, are now focused on demonstrating the feasibility of high bit-rate digital transport technology that can support repeaterless DS-1 rate services in the loop and drop connections for fiber-to-the-curb.

We will continue to team with other Bellcore areas to implement and demonstrate a new HDSL transceiver and necessary signal processing techniques for HDSL applications.

Research will continue on the application of low-cost CMOS VLSI at very high speeds, with emphasis on BISDN and optical interconnect functions.

We will continue to conduct research in selected areas of digital signal processing for telecommunications applications. These include system studies, algorithm research, simulation, VLSI architectures, real-time implementation, and research prototyping. Specific topics would depend on the need, impact, and degree of challenge.

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Project Name: VIDEO SYSTEMS TECHNOLOGY
Project No.: 421306

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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council: RESEARCH & NETWORK | Committee: APPLIED RESEARCH | Forum: NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/84 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
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NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:	Project No.:
SYSTEMS PRINCIPLES	621204
Bellcore Product Manager:	Tel. No.:
A. BERGH	(201) 829-4938

This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
08/14/90

PROJECT OVERVIEW:

Systems Principles Research is involved in work aimed at increasing our understanding of, and our ability to explore design principles for systems of importance to the telephone business. Some of this work is focused on enhancing the utility of the existing network in order to provide new revenue opportunities. An example of this is the continuing work on the High-Speed Digital Subscriber Loop project. Other work is focused on understanding new systems with revenue potential such as our performance analysis of packet switched network architectures and our studies of optical communication network architectures. Still other work is aimed at providing more cost effective ways of pursuing the telecommunications business. For example, because we believe that parallel processing computers will be most cost effective for many applications in the telephone business, we have an effort in exploring new uses for parallel computing.

During the 6 month period under review, members of Division 21240 performed research on a wide variety of topics which can be roughly divided into 7 categories.

1. We continued to work on improving both the performance and our understanding of the L.0 programming language. This included joint work with Division 25930 (P. Deering, DvM) in adding new features to the language, and fundamental studies on the relation between L.0 and temporal logic. An L.0 compiler for the Y machine was written, and we continued to investigate the use of the Y machine as a fast switch.
2. We expanded our research effort in parallel processing.
3. We continued our research on the mathematical foundations of learning theory.
4. We continued to work on communication theory. Of particular importance is the work done on the High-speed Digital Subscriber Loop project. In addition, we have conducted research in optical communication and data compression.
5. We have concluded work on aids for use of the telephone network by the handicapped and disabled. We continue as consultants in this area.
6. We have continued our research on probabilistic modeling, including the performance analysis of packet switched networks and information technologies, and we have continued to do fundamental research on stochastic processes.
7. We have begun to construct experimental research prototypes of

Project Name: SYSTEMS PRINCIPLES

Project No.: 621204

PROJECT OVERVIEW: (CONT.)

actual neural network devices, and we have continued to improve speech synthesis equipment.

During this period we wrote 27 technical memoranda, published 8 papers externally, and presented 14 talks at technical meetings and conferences.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

Y Machine

- An L.0 compiler has been written for the Y machine. This yielded much valuable information on desirable changes to the L.0 language. Work continues on studying the high-speed (600 Mbit/sec) switching capabilities of the Y Machine.

Integrated Communication, Computation and Coordination Environment (IC*) Model of Computation and the L.0 Language

- The IC* Model of Computation is a new, precise model of parallel computation being developed by Bellcore and is the basis of the IC* project. We made a number of changes, and are in the process of making other changes to the environment of the L.0 programming language to improve its speed and make it more object oriented. In particular we are making changes to allow encapsulation and parameter passing compatible with the parallel paradigm. Some of this is joint work with 25930 (P. Deering, DvM). In addition, new theoretical work has shown the relation between L.0 and temporal logic. Some of this is joint work with 21454 (J. E. Cameron).

Parallel Computing

- We continue to write code for the Connection Machine (CM-2) to gain experience in parallel programming. The CM-2 is a new, massively parallel machine. At present, we are writing code to simulate decompression algorithms for 1.5 Mbit/sec TV transmission. We have also found new routing algorithms for parallel computers using the hypercube architecture (such as the CM-2).

Learning and Complexity Theory

- This is research on the mathematical foundations of learning and knowledge acquisition needed to support Bellcore's extensive involvement in machine learning, intelligent control and related fields. We have obtained new results which demonstrate how the quantity of information required to learn logical expressions from examples is related to formula complexity. Additionally, we have been preparing lectures on mathematical theory of learning (which includes rigorous treatment of neural networks) for presentation at Bellcore. We have also been studying an abstract model of computation meant to model a situation in which one party, which has difficulty computing secret or some extra computational power,

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621204

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

tries to convince a second party of some fact which is beyond the second party's power to compute itself.

Light Pulse Encoding

- We have made theoretical studies on the limits of light pulse encoding. These have yielded simple bounds on the performance of code-division multiple access (CDMA) systems. In addition, two level optical encoding schemes have been studied which point toward the improvement of system performance.

High-Speed Digital Subscriber Loop (HDSL)

- We have studied numerical optimization techniques to construct codes for channels with intersymbol interference. This is part of our study of new, multi-channel signal designs that substantially reduce the effects of crosstalk between twisted pairs. Preliminary results indicate that transmission rates of 1 Mbit/sec can be achieved on most subscriber loop channels, and even higher rates are possible by incorporating advanced equalization techniques. This is part of Bellcore's HDSL effort involving organizations 21241 (DsM V. Wei), 21380 (DvM P. Shumate), 27270 (DvM R. Laane), 28530 (DvM T. Scheurer) and several consultants.

Data Compression

- The locally adaptive scheme of Wei, et al. has been recognized as one of the fundamental data compression algorithms by the scientific community. Its performance rivals that of Lempel-Ziv for arithmetic coding. Fast Very Large Scale Integrated (VLSI) implementation has appeared in the literature. We are currently using the algorithm for video and speech compression, and for cluster analysis. This represents a drastic departure from traditional methods and opens new avenues of possibilities. Early results compare favorably with established methods.

Aids to Communication

- We provided an experimental hardware/software computer prototype which has voice recognition, speech synthesis and telephone functions to help the disabled communicate over the telephone network. This includes the performance analysis of alternative and augmentative input/output devices to assist the human interface problems of the handicapped.

  We provided consulting services on the latest available technology for the disabled to the Bell Operating Companies and to the NJ area through our "Disability-Oriented Communication systems" group and the Telephone Pioneers of America.

The Internal Structure of Packet Streams

- We developed a traffic model for the internal structure of packet streams in a single virtual circuit. This model has been used by members of District 21332 (DsM R. Cardwell) in a simulation study

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

of output buffer contention occurring in an (almost) blocking free switch, where the main source of congestion is the occurrence of multiple packets aimed at the same output buffer. The relationship between internal characteristics (such as almost periodicity) and congestion is of great importance and not well understood. For example, this relationship largely determines what traffic measurements must be collected, and what types of customer behavior are harmful to the network.

Simulation Models of Packet Streams

- (This is a continuation of both the previous item and our previous work on "lockstep" in packet streams). We worked out a method to translate descriptive statistics (for example measurements) of a packet stream in coefficients in a model which describes how the stream may have been generated. This method was incorporated in a simulation model built in District 21332 (DsM R. Cardwell), see also the previous item. Currently, we are investigating whether this model can be used to study "lockstep" (i.e. strong almost periodicity) in packet streams.

Periodicity and Persistence in Packet Streams

- We have come to the conclusion that there are two main sources of congestion in packetized communication: "periodicity" (see "lockstep" in previous progress reports) and "persistence", the phenomenon that once we reach the situation where too many virtual circuits are simultaneously in a send mode, this situation tends to persist. We designed models for the study of those phenomena and solved the one modeling periodicity. The one modelling persistence is still under study.

Information Technologies

- We have analyzed the value of information on customer behavior in optimal or near optimal scheduling of generalized Information Providing Service, such as video movies on demand. We calculated measures for the reduction in number of "servers" (e.g. disks with copies of the movie) needed if we have knowledge of how long customers are willing to wait after requesting service.

The Study of Various Stochastic Processes

- We continued our investigations of various aspects of stochastic processes such as queues, buffers in packetized communication, arrival processes in telephone traffic theory, Brownian Motion, and Martingales. We made fundamental contributions to obtaining numerical solutions for stationary distributions in Queueing Systems and Markov Chains. We proved new and numerically useful results about the relationships between studying a queue in continuous time and studying its behavior at special times (arrival epochs, departure epochs). We are continuing our study of the use of Non Standard Analysis in investigations of various stochastic processes such as Martingales and Fractional Brownian Motion, and

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

on the relationships between Martingale Theory and Control Theory problems such as optimal trading of financial securities.

Neural Networks
- o We have been learning how to implement an experimental hardware prototype using neural network integrated circuits (ICs). We will explore connecting these neural chips to a computer in a way to study the theoretical bounds of the learning algorithms.

Speech Synthesis
- o We continue to improve the hardware/software experimental models of demi-syllable speech synthesis to provide real time speech synthesis over the phone network. Joint with 21480 (C. Judice, DvM).

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as communication theory, software services language, parallel processing, and human factors. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

IC* (Integrated Communication, Computation and Coordination Environment): We plan to continue studying the performance of L.0 compilers for the Y machine. We will continue studying the use of the Y machine as a broadband switch.

Neural Networks: We plan to build experimental prototypes of a complex set of neural-network chips that may be remotely accessed by the theoretical neural-network group through their workstations over the Local Area Network (LAN).

Speech Synthesis: We plan to buld and program a research prototype demi-syllable speech synthesiser that can be remotely accessed over a LAN.

Aids to Communication: We will continue to act as consultants to the Bellcore Client Companies. The Americans with Disabilities Act (ADA) passed the House and the Senate and was signed by President Bush on July 26, 1990.

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RESEARCH DIRECTIONS: (CONT.)

Probabilistic Modeling: We will continue to do research on probabilistic aspects of problems from operations research, telephony, and performance analysis of computer and communications systems. We will study the basic properties of the processes involved, numerical problems arising in these areas, and specific problems such as the behavior of packet streams in packetized communications.

Communication Theory: We plan to continue our research on the fast implementation of locally adaptive data compression algorithms and on numerical techniques for signal design in data communications. We plan to continue our research on light pulse encoding for optical communications systems. We plan to resume our research on the general theory of coding communication signals.

Learning and Complexity Theory: We plan to continue our work on the mathematical foundations of learning and knowledge acquisition.

Parallel Computing: We plan to continue our efforts in studying parallel algorithms and parallel programming.

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Project Name: SYSTEMS PRINCIPLES
Project No.: 621204

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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council: RESEARCH & NETWORK | Committee: APPLIED RESEARCH | Forum: NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type: INFRASTRUCTURE | Work Category: PREVIOUSLY FUND | MULTI-YEAR | Start Date: 01/86 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

Project Name:
DISTRIBUTION NETWORK TECHNOLOGY

Project No.:
621306

Bellcore Product Manager:
A. BERGH

Tel. No.:
(201) 829-4938

This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
10/02/90

PROJECT OVERVIEW:

During 1990, exchange-access "fiber in the loop" (FITL) reached cost parity with copper when installed as "fiber to the curb" (FTTC) in selected new-build applications. This benchmark, along with studies showing that FTTC will continue to fall in cost relative to copper, was accompanied by coordination of Bellcore activities to resolve known FITL issues, identify future bottlenecks, and support FITL generic requirements. This project addresses all three areas through research on fiber installation and reliability, powering of the optical network unit (ONU) and remote terminal (RT), and exploration of alternative FITL architectures and strategies for upgrading FTTC in response to demand for high-bandwidth services. The results of this work impact industry through publications and standards contributions, the Bellcore Client Companies (BCCs) through field support and collaborations including a field trial, and numerous Bellcore organizations through two-way collaborations. The time frames for these impacts to be demonstrated through improved or new products becoming available to the BCCs are 0-3 years for the fiber and power research, and 2-5 years for the FITL architecture research.

The project identifies and explores opportunities for applying new optical technologies such as wavelength-division multiplexing and emerging energy technologies to reduce costs. At the same time, the project continues to address technical issues with existing technologies such as fiber and batteries to improve reliability, efficiencies and craft performance. By constructing research prototypes, conducting both laboratory and field experiments, influencing industry standards, and analyzing in detail the anticipated cost savings, this project assures that these benefits will be realized and made available to the BCCs at the earliest time and from multiple vendors. This project helps establish a leading-edge knowledge base at both Bellcore and the BCCs, and it contributes to numerous other Bellcore projects. The three research programs -- fiber, power and FITL architectures -- consistently result in technology transfer through publications and talks (both internal and external), patents and standards proposals. During 1H90, examples included 25 papers, 39 external presentations, 5 standards proposals, 4 patents issued, filed or opened, 20 technical memoranda and 2 special studies. (During 1H90, this project also included research on high-speed digital signal processing for (a) provisioning repeaterless DS-1 service over existing copper loops up to 12 kft,

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PROJECT OVERVIEW: (CONT.)

(b) provisioning 1-way DS-1 service plus 2-way voice telephony over residential loops up to 18kft, and (c) transporting multimegabit/sec services over copper drops < 300 ft in FTTC systems. We view these as key options for evolving to broadband. As of August 1, 1990, this work, known as High-Bit-Rate Digital Subscriber Line or HDSL, has been transferred to Project 421306.)

Fiber distribution and reliability research includes low-cost methods for deployment of fiber in the loop and ongoing applied research in fiber reliability. Mathematical models and supporting computer software for analyzing the mechanical behavior of fiber-optic cables and splices in field-stressed conditions are produced. Bench-top and full-scale in-situ testing is conducted to verify modeling techniques and the integrity of fiber cables and splices under load. Extensive analysis and laboratory testing of optical fibers and fiber coatings are performed to determine their mechanical strength and fatigue resistance in various environments. These results are presented to national and international standards committees for incorportion into fiber optic test procedures. Post-mortem analyses are carried out on fiber-optic-cable field failures in collaboration with members of Network Technology to correlate laboratory tests with actual field conditions. These analyses provide our clients with significant technical input for compensation claims against manufacturers. This work has numerous two-way linkages to projects in Divisions 21130 (V. Keramidas, DvM), 21140 (B. Reagor, DvM), 21310 (P. Kaiser, DvM) 27210 (D. Burpee, DvM), 27510 (D. Shelton, DvM) and 24230 (E. Gould, DvM).

Energy systems technology research includes applied research on systems for powering both FITL and Integrated Systems Digital Network (ISDN), and is centered on our continuing theme of Minimum Energy Design for Telecommunications (MEDTEL). Due to the documented high costs associated with powering each watt in ONUs and ISDN network terminations (NT1s), our focus is on demonstrating energy-efficient designs, incorporating power limits into Bellcore requirements and shaping standards that will accommodate the powering down of inactive circuits. This is a natural extension of our modified digital-loop-carrier program that demonstrated greater than 50% energy and power savings for narrowband services, leading to the revision of TR-TSY-00057. Anticipated inflation in energy costs, combined with the present emphasis on increasing battery reserve time at RTs (remote terminals) adds to the cost of powering outside-plant electronics. Therefore, research will address alternative powering architectures and technologies. Fuel cells are being investigated for powering an RT continuously from piped natural gas, relegating the electric grid to a backup facility. New technology low-pressure nickel-hydrogen batteries and improved nickel-cadmium batteries are being investigated for FITL applications such as ONUs. The Chester Outside Plant Laboratory long-term field trial of 10 ONUs will continue to gain insights into battery longevity and temperature extremes for FITL

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PROJECT OVERVIEW: (CONT.)

applications. Enclosure energy-management schemes requiring less energy will continue to be studied at our Chester Laboratory. We plan to focus on reliable and economical space conditioning for Passive Photonic Loop (PPL) nodes in 1991. Narrowband ISDN line-protection work on sealing current will be continued in the New Jersey Passaic trial, and extended to a central office in Florida. Further research on Bellcore's thin-film fuel cell will be pursued through a research collaboration with an outside facility. The energy systems research has strong two-way linkages to projects in Divisions 27270 (R. Laane, DvM), 27410 (M. Schwartz, DvM) and 27450 (F. Zupa, Dvm).

Optical network architecture research includes exploration of both near-term and long-term options for upgrading FITL capabilities from narrowband to broadband at lowest cost, with minimal disruption in the distribution plant and as service demands warrant. Near-term FITL options being investigated for providing wideband (< 45 Mbit/sec) and perhaps early broadband (> 45 Mbit/sec) services include copper-plus-coax or copper-plus-fiber drops. Long-term options for broadband center about evolving from FTTC to a passive "fiber-to-the-home" (FITH) architecture (such as the Passive Photonic Loop). To ensure that this meets the objectives above (lowest cost, minimal disruption and demand driven), then technology, power, space and environmental requirements must be explored for each of the key steps in the evolution. The implications of increased bandwidth per subscriber and the lower implied pair-gain on the future central office are also being considered. The objective of this work is to conceive a new means of applying optoelectronic technologies near the switch for providing maximum service flexibility at lowest cost. Research is carried out from a service-needs perspective through laboratory experiments, analytical modeling and detailed cost studies. Advanced software tools such as FINESST have been designed for accurate layout of serving areas with the architectural options. Planning for a field trial of the Passive Photonic Loop is underway with one of the BCCs for 1992. This research has had major impact at Bellcore through stimulation of many successful collaborations both inside and outside of Applied Research. It maintains strong two-way linkages to Divisions 21310 (P. Kaiser, DvM), 28530 (T. Scheuerer, Dvm), 27210 (D. Burpee, DvM) and 24230 (E. Gould, DvM).

PAST YEAR RESEARCH ACCOMPLISHMENTS:

This project's accomplishments during the past six months continue to demonstrate how new technologies can be employed to reduce BCC costs and provide opportunities for new services or network evolution. The following examples illustrate the value of this work in the areas of fiber reliability, low-cost single-mode connectors, installation of FITL, efficient, extended powering of loop electronics including FITL,

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

powering of ISDN, high-bit-rate DSL (Digital Subscriber Line) for existing loops, new architectures for FITL that require power only at the end terminations ("passive loops"), and software tools for analyzing FITL options.

Fiber Media Reliability Research

- o Substantial progress has been made in fiber media reliability research including optical fiber testing programs in the areas of stress-free aging, static and dynamic fatigue, and the influence of fiber coatings and environmental contaminants. Bellcore now leads the field in fiber reliability research, and was first to measure the corrosion of optical fiber surface in water and correlate the resulting surface roughening with reductions in fiber strength. Research is continuing on the long-term reliability of optical fibers and measurements of the mechanical properties of fiber coatings that will influence the strength of fatigue resistance of fiber. Investigations have also continued on the long-term reliability of fiber splices and field failures of fiber splices and distribution cable sheaths.

  We are continuing to play a very active role in the Fiber Reliability Working Group 6.6.8 and Fiber Coatings Committee 6.6.7 within the Telecommunications Industry Association (TIA). We developed five Fiber Optic Test Procedures (FOTP) for testing of optical fibers by vendors prior to cabling, and presented them to the Electronics Industry Association (EIA) FO6.6.8, and are providing comments on the rewrite of five FOTPs within 6.6.7.

  There is continuing interest in the support of post-mortem analyses in collaborations with Network Technology, Division 27210, (D. Burpee, DvM) of fibers that have failed in the field. Instances of large surface flaws on fibers and poorly coated fibers have been seen. LID (Local Injection/Detection) devices which use microbends to couple light energy into fibers have been the subject of increased attention and investigation. Substantial coating damage has been observed and quantified relative to the fiber strength reduction from LIDs.

  Additional attention is being brought to determining the reductions in fiber strength that occur due to cabling, installation and subsequent field aging. We have designed and begun to construct a new long-gauge-length fiber test lab to investigate the propagation anf failure of the larger flaws that exist in optical fibers, which is expected to determine their actual strength and useful life under typical field conditions. This lab is essential in determining the correlation between tests and reality.

Power Plant Survivability of Natural Disasters

- o This topic became very current through 1989 with the loss of telephone services that accompanied hurricane Hugo and the San

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Project No.:
521306

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Francisco earthquake. Two recently completed projects addressed the cry for more reliable, longer lasting emergency carryover for outside plant remote terminals. This issue hastened our hand-off of these results both within and outside Bellcore.

Our recent experience with sealed lead acid batteries, gained through substantive testing at Argonne National Laboratory and reported to Power SMEs and to the battery industry, showed that battery capacity was dependent upon cell orientation. Also, capacity degradation with discharge/charge cycles was found to occur with gelled electrolyte cells. Our research suggested ways that low capacity could be corrected. The battery industry has taken up our suggestions. Products being made available for RT (Remote Terminal) application today consequently offer these improvements in capacity over that of cells in service during recent natural disasters.

The other part of the solution to longer carryover time is to reduce the battery drain presented by the digital loop carrier (DLC) equipment load. Our laboratory modification of a Northern Telecom DMS-1 Urban showed that energy dissipation could be reduced by two-thirds while, at the same time, making the system more reliable and less expensive to maufacture. The relevance of this result to the issue of survivability through natural disasters is that if the same telecommunications function can be provided at one-third the energy, then a given size battery would carry over the system for three times the reserve time. In March, 1990, a revision to TR-TSY-00057, describing requirements for DLC systems, was announced based on these results. A 55% power reduction is expected. This work was accomplished by a cooperative effort with Division 27450 (F. Zupa, DvM) in conjunction with Division 27410 (M. Schwartz, DvM). Power survivability through natural disasters has been made the theme of the 1990 International Telecommunications Energy Conference. This conference program committee is led by Bellcore personnel. We plan to see these solutions through to full implementation.

Fuel cells powered by natural gas may offer an unusually reliable, environmentally clean, continuous source of power for RTs. Electric utility power, the primary source today, would be used without batteries only for emergency backup, or possibly not at all. Our preliminary estimate is that the 20-year life-cycle costs (including present equivalent energy costs) of appropriately sized fuel cells and electric power supplies with 8-hour battery backup would be comparable. (Most currently available fuel cells are significantly larger or smaller than appropriate for powering an RT, hence, one aspect of our planned effort.) We plan to analyze the smallest of the large fuel cells (10 to 20 kW range) for developing a more accurate system model, including reliability, and install and test one of these at our outside-plant facility at

Project Name:
DISTRIBUTION NETWORK TECHNOLOGY

Project No.:
621306

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Chester, NJ.

Powering of Fiber in the Loop (FITL)

- The costs associated with providing reliable uninterrupted power for an Optical Network Unit (ONU) on the customer end of a fiber were documented in TM-TSY-013583. These studies show that any degree of reliability, up to and including that of central-office-provided power, can be obtained at a commensurate cost. A wide-based study group within Bellcore was convened to reach consensus on some aspects of powering fiber in the loop. Unanimity was reached on two points: the ONU should accommodate a power-down mode, and power for the ONU should be sourced generally as close to the ONU as the distribution architecture permits. Savings on this point are most pronounced on long loops.

  The costs associated with powering each watt of consumption at the customer end of a fiber at the curb or home are shown to be high. Alternatives considered are over network copper, from the curb, from customer's AC supply, and over the fiber (optical power). The high cost provides motivation to reduce power consumption of the ONU. To this end, a consensus was reached by the FITL Task Force that the ONU will accommodate a power-down mode. This decision will lead to substantial savings in first cost and operations cost. It sets a good example for broadband ISDN to follow. This work was presented at Fiber ComForum, National Fiber Optics Engineers Conference, and Supercomm. We plan to pressure manufacturers to develop energy efficient architectures and hardware. At the same time, we will work the standards, requirements and technology issues to speed implementation of FITL.

Thin Film Fuel Cells and Gas Sensors

- A very broad device patent was issued September 5, 1989, on the thin film fuel cell. The salient points of this new energy conversion device are that it is thin and one-sided and can be produced on inexpensive substrates such as capton; it operates at room temperature and pressure with mixed gas (fuel and air); and that it operates on several hydrogen based fuels. All of these attributes have the prospect of yielding a low cost in volume production. The most interesting BCC application envisioned is a compact reserve power supply for a remote terminal or controlled environmental vault. This would occupy approximately 20% of the volume of the 8-hour battery which it would replace, and it would run the load for twice the reserve time. Paramount is the fact that indefinite extended reserve with the present battery system cannot be achieved when the outage covers a broad area that includes serveral sites. But with a fuel cell, indefinite reserve is contingent only on the refilling of the fuel tanks.

  "Nature" the international journal of science, published Bellcore's official disclosure in a letter on February 7, 1990. We were

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Project No.: 621306

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

deluged by media coverage because "Nature" editors leaked the results. The fuel cell has received more exposure than any other Bellcore accomplishment. It was covered by BBC, C-SPAN, Business Week on two occasions, The Wall Street Journal, The New York Times, The Washington Post, The Los Angeles Times, Japan Times (front page) and many more. We now have a licensing philosophy and a licensing package to offer interested companies. Our plan is to form a 2-year research collaboration with another party for purposes of bringing the technology closer to telephone application.

FITL Planning Software

o Design, coding, testing and documentation were completed on three key programs in the Fiber Network Economics Software System (FINNEST), an interactive software system which evaluates and optimizes alternative fiber loop network architectures. TMs (Technical Memoranda) outlining the sites, services, and equipment interactive database editors were completed (TM-ARH-015153, TM-ARH-016362, TM-ARH-016019). Collaborations are currently being pursued with other Bellcore technical areas and BCCs to turn FINNEST into a Bellcore software package.

Switching and Switch Interfaces

o Research continued on the application of new technologies at the interface of the distribution network. An analysis of asymmetric packet-switch modules with channel grouping was completed. Performance analysis of a 3-stage modular packet switch architecture that should be scalable to more than 10,000 ports was also completed. Ongoing research on the loop network and broadband switch relationship has explored the relative merits of input and output queuing in a high-speed packet switch, and we have been able to prove the counter-intuitive result that input buffering is better than output buffering under some traffic and service mixes (TM-ARH-017039; TM-ARH-017038).

We have explored r-for-N protection schemes for fiber loops (TM-ARH-018288), following up on last year's successful work on the impact of passive loop architectures with route diversity on incremental cost and access link availability. Recent results show that some r-for-N protection arrangements with diverse facility routing may cut access link unavailability by more than two orders of magnitude below the unavailability provided by 1:1 protection with diverse facility routing.

Related accomplishments in all areas include significant participation (papers, committees) in major conferences including the Optical Communications Conference (OFC), Globecom, the National Fiber Optics Engineers Conference (NFOEC), the International Communications Conference (ICC), the Eastern and National Communications Forums (ECF and NCF), the Conference on Lasers and

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Electro-Optics (CLEO), the European Conference on Optical Communications (ECOC), The International Conference on Acoustics, Speech and Signal Processing (ICASSP), the International Telecommunications Energy Conference (INTELEC), and the Workshop on Passive Optical Networks for the Local Loop (PON).

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies and systems. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Research in the installation, repair and reliability of fiber optic networks with emphasis on fiber-in-the-loop. This effort requires conducting numerous laboratory and "real world" field experiments to stress the technologies to find their weaknesses, and then to correlate their behavior with our models and analyses. This effort includes failure-mode analyses for the BCCs.

Research directed to the analysis of cost effective powering and environmental-control architectures that utilize new technolgies, minimize energy consumption, and which will serve future Bellcore Client Company needs. Significant efforts are focused on the powering architectures and technologies which will be necessary to support fiber-in-the-loop.

Research on strategic options using multiwavelength passive optical networks for increased capabilities, demand-driven upgrading, and/or reducing costs in broadband optical access networks.

Teaming with other Bellcore areas to implement, test and demonstrate software for planning and analysis of future optical networks.

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Project Name:
DISTRIBUTION NETWORK TECHNOLOGY

Project No.:
621306

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Bellcore Product Name:
APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		Start Date: 06/86
			Completion Date: 12/92
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
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BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR- ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

Project Name:
NETWORK CONTROL

Project No.:
621307

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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
10/02/90

PROJECT OVERVIEW:

The Bellcore Client Companies have a need to evolve their primarily voice networks of today to the Information Networks that their customers will demand in the next century. Simply stated, the Information Networks of the future will provide any type of information, voice, image, video or data, to anyone, at any time, in any place, and at reasonable cost. Bellcore has articulated this vision in a product called the Information Networking Architecture, or INA. The Network Control Research project will conduct applied research to establish one portion of the technological foundations of the Information Networking Architecture; the portion of that architecture which consists of the underlying transport network, its control structure, and the software systems which implement its control structure. It is the goal of this research to learn how to build and control a transport infrastructure that supports greatly increased bandwidth and increased variety in traffic characteristics, while at the same time continuing to deliver the reliability we have come to expect from the current network. Our work in 1991 will consist of research on survivable network architectures and network design, on the management of traffic and connections within these networks, and on the modeling of large scale networks and their operating systems. All this work is aimed at the eventual goal of achieving a powerful and robust underlying transport and delivery network for the future Information Networks of the Bellcore Client Companies (BCCs).

We will continue our work towards the conception of survivable and cost-effective fiber network architectures. Our work in the past resulted in a software product called Fiber Options that has seen widespread use within Bellcore and by network planners in the BCCs as an aid to their strategic planning. We will extend this work to develop algorithms and computer programs to identify areas in the local exchange network where fiber optic rings can be cost-effectively deployed. These algorithms will also indicate if other means, such as diverse protection, are more suitable to achieve protection for certain buildings. This work will directly benefit the Bellcore Network Planning System, Division 24240 (C. Pack, DvM) and the SONET (Synchronous Optical Network) project, Division 27240 (G. Ritchie, DvM).

Work on network traffic control will be directed at future broadband networks, and in particular, the portions of those networks which

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carry Asynchronous Transfer Mode (ATM) traffic. We will continue our close working relationship with the Broadband Project in the Network Technology Area, Division 27140 (S. Walters, DvM). We will study the problem of call admission control and traffic routing. We will seek to determine the level of statistical multiplexing gains that are achievable for such bursty services as packet video and Switched Multimegabit Data Services (SMDS). Our work in the past showed the critical connections between traffic parameters, switch resources, and SMDS service quality.

One of the objectives of the Bellcore Information Networking Architecture vision is the segregation of the future Information Network into a Services Segment and a Delivery Segment. The Delivery Segment consists of network elements and a control structure that will support new services and new network operations applications. Software functions which are appropriate to transmission and switching products are in the Delivery Segment. Software functions which should be under the direct control of the Local Exchange Carrier or its customers are in the Services Segment. The proposed separation may be attractive from a BCC business perspective, but the achievement of adequate real time performance of a network made up of segregated switches and services software requires research advances. One aspect of our work will be the investigation of methods to maintain highly reliable call or connection records in network elements, but still make them available to network services applications in real time. Network traffic control, fault isolation, technical limits on billing policies, and service response time are all dependent on virtual circuit information stored in switching elements. Our work in the past years on real time call processing, using parallel computers, provides a base of knowledge upon which to build. This project will collaborate closely with three Bellcore Centers to develop technology that will advance us toward the INA goal of establishing a powerful and robust Delivery Segment: Network Services Research, Center 214 (S. Personick, AVP); Network Architecture, Center 271 (D. Leeper, AVP) and Computing Systems and Architecture, Center 259 (D. Kessell, AVP).

Modeling and analysis will be important in developing an understanding of how future Information Networks behave under normal and adverse conditions. The simulations that are to be carried out will be aimed at the broad-level behavior of systems, and are not detailed simulations of individual network elements. One area of major concern is quantifying how the architectural design of software systems determines how these systems will perform. The objective is to analyze the performance of different architectures before detailed code writing is begun. We will also collaborate with Bellcore Software Technology and Systems, Division 25910 (C. Riley, DvM), in an analysis of the tools that are currently available from the commercial market, from the MCC (Microelectronics and Computer Technology Corporation) Software Technology Program, and from academia. The objective is to identify a common set of tools that

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could be used by Bellcore in modeling different systems.

Although the Network Control Research project is new, it represents a bringing together of already existing individual research programs in this area, with the intention of reinforcing and expanding this effort.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

The main thrust of this project is the advancement and demonstration of critical interconnection and packaging technology to be used in future broadband networks. Notable accomplishments during this reporting period include the demonstration of an experimental prototype optoelectronic integrated circuit receiver chip that works at speeds in excess of 1 Gbit/sec, the delivery of a 622 Mbit/sec SONET-like transmission system for an Advanced Television demonstration, a standard cell integrated circuit design system developed in collaboration with Division 21340 (J. Bellisio, DvM) and development of a novel method for generating multiple pseudo-random noise for neural network applications. Four division members were elevated to the Institute of Electrical and Electronics Engineers, Inc. (IEEE) senior member grade last year.

Broadband Network Switching Consultation

- We contributed regularly to numerous Bellcore groups in the Broadband Network definition and standards projects. We continued to work closely with the members of the Next Generation Switch project under Division 27140 (S. Walters, DvM), as well as the T1S1 and CCITT (International Consultative Committee on Telephone and Telegraph) negotiating teams responsible for Broadband access standards in the same division. Detailed Asynchronous Transfer Mode (ATM) translation table technology capabilities and cost estimates were provided to Division 27270 (R. Laane, DvM) in support of Broadband network control standards development. We provided technical analyses of alternatives in protocol message processing and call record access times in distributed switching systems and exchange terminations in general. We continue to support the development of documents such as the Broadband Switch Framework TA (Technical Advisory).

Packet Switching Controls

- Our investigations into Broadband congestion control continued with the application of SMDS (Switched Multimegabit Data Service) traffic models to recent Broadband Switch architectures. In collaboration with Divisions 27120 (L. Linnell, DvM), 21490 (W. Sincoskie, DvM), 27140 (S. Walters, DvM), we analyzed worst case models of ATM packet traffic within the limits of SMDS Quality of Service constraints. This work showed the critical connections

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between traffic parameters, switch resources, and SMDS service quality, especially the relationship between burst length, switch queue size, and the quality of service delay parameters. Follow up work will resolve switch dynamics questions showing how rapidly congestion occurs and abates, as well as the time frame in which a Broadband exchange termination can be expected to take active measures to counter any such problem. We assigned a member of this Division to work in Divisions 27120 and 27140 as part of a technology teaming activity.

New Research Initiatives Task Force

- o A task force was formed to identify new research areas related to software that could be built upon the experience of people currently working on computer aided design tools and other hardware related research. This group worked part time over a period of about four months reviewing memos and interviewing technical and management people in various areas - especially Software Technology and Systems, Technology Applications, Network Planning and Applied Research. They developed an initial list of research issues, and derived from part of the list a number of project proposals. These proposals were reviewed by the Applied Research Lab 213, and a subset was presented to Software Technology and Systems management. A research program on applications of Performance Modeling tools has developed out of the conclusions of this task force.

622 Mbit/sec SONET-like System for Advanced Television and Datacycle Experiments

- o With Division 21340 (J.Bellisio, DvM), we successfully demonstrated digital transmission of ATV using a SONET-like 622 Mbit/sec transmission protocol over 42 kilometers of optical fiber at 1.3 microns using potentially low cost media that would be suitable for the subscriber loop. This system was modified and combined with a coherent experiment (in collaboration with Division 21310 P. Kaiser, DvM) to demonstrate digital ATV transmission of a coherent optical link for subscriber network distribution. Division 21450 (G. Herman, DvM) has asked for a copy of the transmission hardware to support an ongoing research effort in database management (Datacycle) and storage, using optical fiber as the storage media. Copies of this system have been delivered.

Terabit per Second Switch Fabric Study

- o During this year a major initiative was begun to determine suitable architectures for a terabit-per-second switch and to analyze contending switch fabrics which would be required to widely deploy BISDN. The preliminary conclusion is that the switch fabric is feasible with state-of-the-art technology but would be difficult. Control and software will be extremely difficult issues. A special report on the committee's activities will be written. Because of the committee's work, research on fabrics in Bellcore now includes examination of scaling issues, and has resulted in

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

several novel new architectures that will be reported in 1990.

Standard Cell IC Design System Using Schematic Capture and Symbolic Cells

- To expedite the design of prototype Very Large Scale Integrated Circuit (VLSI) chips of high complexity (e.g., fifty thousand transistors or more), a system of CAD (Computer-Aided Design) tools has been assembled and written that takes the logical specification of a chip and automatically creates the circuit layout. This system is a collaboration with Division 21340 (J. Bellisio, DvM). Many experimental chips for a prototype Advanced Television system experiment are currently being generated using this tool.

Simulation and Analysis of Integrated Circuit Timing

- An interface to timing simulators has been coded that enables Bellcore chip designers to run these simulators and examine speed performance results on the screen. A new timing simulator, called GONGA, has been written and tested. This simulator has the efficiency of a logic simulator, but is able to determine delay times, which is not possible with standard logic simulation.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as network technologies and systems. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Carry out research aimed at the Information Networking Architecture objective of achieving a separation of the Delivery Segment and the Services Segment, while insuring the highest levels of reliability in the Delivery Segment.

Research network management strategies, traffic routing strategies and network design methods for broadband networks, with an emphasis on the Asynchronous Transfer Mode of packet transport.

Research algorithms for the design of survivable networks, with an emphasis on determining areas within a network where SONET rings can be cost-effectively employed.

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Project Name: NETWORK CONTROL

Project No.: 621307

RESEARCH DIRECTIONS: (CONT.)

Research into methods of modeling operations systems and networks made up of network elements with distributed control.

Research into modeling of systems at the level of their software architecture. The purpose is to analyze the performance effects of the choices made in program design and organization before the detailed code is written.

Project Name: **NETWORK CONTROL** — Project No.: **621307**

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Bellcore Program Manager: **A. BERGH** — Tel. No.: **(201) 829-4938**

Bellcore Subject Matter Expert: **J E BERTHOLD** — Tel. No.: **(908) 758-2992**

Bellcore Product Name: **APPLIED RESEARCH**

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 06/86 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 — Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET — CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-1550
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:
NETWORK SYSTEMS

Project No.:
621405

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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

A software-defined public network, providing abundant, ubiquitous communications services, supporting the rapid introduction of new features and services with a multitude of competing suppliers of network components, is a goal shared by Bellcore, the Bellcore Client Companies (BCCs), and many in the telecommunications industry. The transmission and switching technologies needed to provide an integrated services broadband transport capability for such a network are becoming increasingly well-understood. However, the architecture and algorithms for the advanced network systems that control transport resources and offer this functional, flexible "intelligent" network are much less understood. Such advanced architectures can reduce BCC costs for provisioning, maintenance, and data administration, and can allow expanded voice/data/video service capabilities suitable for both business and residential customers.

Major research advances are required to realize these benefits. For example, the deployment of ultra-high capacity transmission and switching systems creates a need for correspondingly new techniques for congestion management, resource allocation, and failure recovery for the public network environment. The desired features cannot be achieved without significant advances in software environments for service specification and in software design and development techniques for large, high availability, real-time distributed systems. Similarly, the increasing demands placed by the intelligent network on its signalling network and on network databases generate new requirements for high capacity distributed databases and signalling networks that are far beyond the current state-of-the-art. The goal of this project is to achieve the necessary advances in these areas.

Work on network systems management focuses on control algorithms for managing the resources of the evolving public telecommunications network. Questions to be addressed include those posed by radical changes in network switching and transmission technologies, such as Asynchronous Transfer Mode (ATM) transport, as well as nearer term network control and management issues generated by the evolution toward increasingly more intelligent network elements and systems. In the area of future broadband networks, we are investigating congestion and flow control algorithms applicable to Broadband Integrated Services Digital Networks (BISDN). Because this network will support a

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NETWORK SYSTEMS

Project No.:
621405

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greater variety of services and will operate at transmission and switching rates orders of magnitude faster than today's packet networks, it will require new strategies to control network congestion and provide the necessary performance guarantees required by each service class. Our analytical work is complemented by simulation techniques to provide tools to better understand the dynamics of complex systems. The research on current network evolution emphasizes techniques to allow for the real-time reconfiguration of Digital Cross-Connect System (DCS)-based trunk networks. Applications under study include network reconfiguration strategies to deal with facility failures (survivability through automatic fault-recovery), or unanticipated traffic fluctuations (improving the efficiency of use of network facilities). We focus on distributed algorithms and stochastic optimization techniques in our studies of network reconfiguration.

In the area of network software architecture and implementation, we sought initially to understand why telecommunications software is so much more complex and difficult than software for other large applications. For 1990, we intend to take the insight gained and apply it in three major areas. First, we are investigating specification languages and environments that facilitate the specification of the desired behavior of new network services. We seek tools that are precise, complete, and yield executable code (for simulation of the new service). These tools must also allow reasoning about the behavior of the new service in the context presented by all other services that the system executes concurrently (e.g., can the new service result in a deadlock in the network; does the new service conflict in execution with other services?). We are investigating logic-based languages and the use of some expert systems technologies in this area. Second, we are attempting to define an extensible software architecture for telecommunication control software. We wish to demonstrate, through a research prototype, the use of parallel and distributed programming techniques to deal with software evolution (introduction of new features) and scalability as fundamental objectives of the system. We plan to address a wide range of software issues that arise in large telecommunications systems including network operating systems, programming paradigms, portability, system monitoring and maintenance, naming and addressing, as well as the safe and correct interaction of local and remote software components. Our third area of emphasis is in software fault-tolerance. The complexity of telecommunications software, combined with the extraordinary availability requirements for network elements in the public network, suggest that the ability of a system to tolerate errors originating in specification or design is essential. We wish to generalize the traditional approaches to software fault-tolerance and develop a more formal model that would allow fault-tolerance considerations to be included in a standard, open software environment for telecommunications systems.

Our research on network control architecture addresses the database

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621405

PROJECT OVERVIEW: (CONT.)

technology and network control architecture issues associated with evolution of the exchange network to an intelligent network supporting ubiquitous access to service features, customized routing, logical (person-specific) addressing, and personal services. Such a network generates database query volumes and signalling traffic volumes far in excess of the capability of today's technologies. The problem is further compounded by increased complexity of queries at these high volumes.

In addressing these problems, our research emphasizes exploitation of the high interoffice transmission bandwidths available with single-mode fiber to create highly efficient distributed database systems capable of supporting enormous transaction volumes. This work has three components: (1) analytic and simulation studies to explore alternative control architectures and distributed database schemes; (2) definition and extensions to data models and query languages to support network services through shared access to a network-resident database system; and (3) the prototype implementation of a novel broadband data distribution architecture to assess feasibility and permit understanding and resolution of key technical issues. In 1990, we are extending the prototype initiated in 1989 to explore fault-tolerance and the distribution of prototype functionality, and to use the prototype as an experimental platform for prototyping selective network services with data access demands that are not met with today's technologies.

In the past six months, we published 19 technical memoranda, gave 12 external talks, published 11 technical papers and filed 4 patent applications.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

VLSI Relational Data Filter

- A critical technology issue in architectures that depends on the broadcast of large amounts of data is the electronic subsystem that examines the data appearing in the broadcast channel to detect and copy items of local interest. In 1989, we successfully implemented a 2 micron research prototype of a relational filter that performs relational database selection predicates on data stream contents. In the second half of 1989 we explored extending the capabilities of the current chip to take advantage of the on-chip arithmetic-logic-unit (ALU) to perform more complex on-the-fly filtering needed to resolve spatial queries to identify the closest neighbor, and to satisfy temporal data requests. The overall design and implementation process used to implement the chip represents a novel combination of PROLOG (a logic based programming language) architecture simulation with a silicon compiler Computer Aided

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NETWORK SYSTEMS

Project No.:
621405

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Design (CAD) tool that contributed significantly to the rapid design and ultimate success of this VLSI circuit (Very Large Scale Integrated) implementation. This design process is described in TM-ARH-014295.

Performance Studies in Broadband ATM Networks

- Traffic management in Asynchronous Transfer Mode (ATM) packet networks is an important issue to avoid congestion, and consequent delays and packet losses. We have compared network-level and user-level performance of three access control mechanisms for congestion management: rate-based windows ("leaky buckets"), end-to-end acknowledgement, and congestion feedback acknowledgement. We studied their performance using a cell-level simulation of an ATM network. We found that at the network-level, "leaky buckets" perform well, while neither acknowledgement based mechanism is adequate. However, assessed from the user's perspective, "leaky buckets" also fail to provide satisfactory service. Our simulation results indicate that further studies of intranetwork queueing and routing are needed to adequately control congestion and supply assured quality of service to end-users. This work is documented in TM-ARH-013122, and a paper was presented at Globecom'89. Continuing work includes the measurement and analysis of Local Area Network (LAN) traffic over fine time scales (i.e., millisecond resolution) in order to obtain and characterize real-world traffic.

Timed Logic Programming Paradigm for Service Specifications

- Presently, the current service creation process is lengthy and vendor-dependent. Generally, service creation consists of four intermediate stages: behavioral specification, network design, software design, and implementation and testing. The testing and implementation stage is usually the most time-consuming part of the present process. In most cases this is due to incomplete and/or incorrect behavioral specifications. Behavioral specifications usually consist of cause-effect requirements, real-time requirements, and time independent invariants. Most existing service creation tools and environments focus on the representation of cause-effect requirements and mechanisms for detecting interactions in such representations. By checking cause-effect pairs, signal ambiguities can be easily detected when the same conditions (causes) lead to different effects. However, when integrating new features into an existing system, incompatible temporal behaviors and/or violations of invariants can cause problems. The goal of this project is to determine if the expressiveness and built-in control mechanism of logic programming could be useful tools in facilitating the verification of specification and integration of new services. Much effort has been devoted to i) selecting a proper formalism for representing specification in the logic programming paradigm; and ii) incorporating the temporal notion to resemble the evolution of service behaviors over time. A paradigm is being developed to

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

allow service designers to simply provide a set of temporal transition rules and invariants as specifications, and then to allow the designer to query the service behaviors as desired.

Discrete-event Object-oriented Simulation Environment

o Telecommunications software systems are notoriously complex and hard to change. The main objective of this project is to investigate ways to allow complex software systems to be more easily designed to be extensible and reusable, so that fewer person-years are needed to develop and maintain them. This project explores ways to define software systems via modules that can be easily extended by composing reusable submodules. The system can then be debugged using software monitors or probes. Software engineering approaches such as object-oriented programming address some of the issues, in particular, modularity and reusability, through the notions of encapsulation and inheritance. However, it does not address the issues of structured composition, system extensibility or system monitoring. A programming paradigm based on the object-oriented language C++ has been developed. A simulation environment, DOSE (Discrete-event Object-oriented Simulation Environment) is being built. A preliminary version of DOSE is functional.

L.0 -- An Executable Specification Language

o L.0 is a new executable specification language specifically designed to better facilitate specification and rapid prototyping of communication systems. Communication systems are reactive (event-driven) real-time systems which have many interacting components at any given instant. To facilitate the description of time-based relationships between events and data, L.0 incorporates an explicit notion of logical time or program step. Communication systems are composed of many subsystems, hence L.0 provides easy flexible module composition via constraints. To enable users to specify "what" should happen without describing "how" it should happen, L.0 is a rule based language. To more easily describe the dynamic nature of telecommunications systems, L.0 rules can instantiate and/or remove other L.0 rules. TM-STS-014531 discusses using L.0 to model telecommunications services within the context of layered architectures such as X Information Systems (XIS) or Operations Systems Computing Architecture (OSCA). An invited talk on L.0 was given at the University of Arizona. L.0 was also presented at SETSS '89, "IC*: an Environment for Designing Communications Software." L.0 is presently being used experimentally at two universities.

Distributed Resource Counters

o When real-time constraints must be satisfied by large systems under heavy loads, even simple problems become difficult to solve. As a model for maintaining a fixed maximum number of lines between two customers in a private virtual network, we investigated one such

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

problem whose solution is complicated by all three factors. We formulated the problem as a real-time resource counter on a distributed system, and developed a real-time correctness condition for the counter. We then investigated several approaches to implement the counter, and compared their performance to account for message processing delays. The results of the performance studies are also used to develop heuristics for configuring a resource counter on a distributed system.

Non-stop Software Updates

o In the telecommunications network, where service must be continuously available, the cost of stopping a system to install new software may be unacceptable. This is particularly likely to be true if software modifications occur frequently, which is possible in the future as increasing numbers of new features are introduced. In 1989, we analyzed our non-stop update approach with respect to the availability and maintainability requirements for switching systems, as defined in Local Access Transport Area (LATA) Switching Systems Generic Requirements, and presented our findings at the Institute of Electrical and Electronics Engineers, Inc. (IEEE) Software Engineering for Telecommunications Systems Conference. We also studied a method for extending an existing updating system to a distributed environment. These extensions allow distributed programs written, using the remote procedure call paradigm, to be dynamically updated. Our approach scales to a geographically distributed computing environment and supports computer systems that contain heterogeneous hardware and software. Programs that execute on computer systems owned by multiple administrative entities can also be updated using this approach. We presented the results of this extension at the IEEE Conference on Software Maintenance.

Telecommunications Software Research Prototype

o The current generation of telecommunications software is extremely complex (both in structure and operation), has limited extensibility, and is difficult to maintain. These factors limit the growth potential and the range of new services that may be reliably offered. Much of this is due to unplanned software growth and the inherent lack of scalability of the programming techniques used in system development. We have begun an experimental prototype of a novel communications system intended as a vehicle to examine these software architectural issues and to investigate the use of modern programming techniques to overcome some of these software problems. We have started the assembly of video, audio and graphical station equipment in each end user's office, and have begun to install switching software and control processors to interconnect user stations. Once the hardware is in place, we plan to address a range of software issues that arise in large telecommunications systems including network operating system, programming paradigms, portability, system monitoring and fault

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

recovery, naming and addressing, as well as the safe and correct integration of local and remote software components.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as real-time systems, control infrastructure, service reaction and interaction, and database management. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the project.

RESEARCH DIRECTIONS:

Examine the feasibility of open architecture for network software systems, consistent with traditional reliability and performance standards, but facilitating rapid introduction of new network capabilities.

Study the architecture for network control functions, including the design of very high capacity, distributed network database systems.

Study software tools and techniques for network service specifications that will facilitate the rapid introduction of new network services by the Bellcore Client Companies.

Study control algorithms and develop evaluation techniques for managing resources of the current and future public network.

Project Name: **NETWORK SYSTEMS**

Project No.: 821405

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Bellcore Product Name: **APPLIED RESEARCH**

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 06/86 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name: MULTIMEDIA COMMUNICATIONS	Project No.: 621406
Bellcore Product Manager: A. BERGH	Tel. No.: (201) 829-4938
This Project is a Component of the Bellcore Product: *APPLIED RESEARCH*	
Significant Change Date: 08/31/90	

PROJECT OVERVIEW:

This project addresses human networks and technology-oriented issues on which the services offerings of the evolving intelligent, broadband network depend. It advances a vision of an information society in which individuals communicate with each other and with information and computing resources for work, learning, social relationships and leisure time activities despite barriers of distance, time and medium. In this vision, individuals and organizations are able to use communication networks to share ideas, information, and electronic work spaces, to handle floods of information, and to reinforce relationships and social values while maintaining control over their privacy and personal communications environments. The project furthers understanding of multimedia communications services, and researches technologies for realizing them over the networks of Bellcore Client Companies (BCCs).

Specifically, the project investigates multimedia (and multi-party) real-time conferencing and collaboration, multimedia information access and dissemination, multimedia messaging, tools and concepts for advanced user interfaces, and security and privacy issues. It studies the software, network architecture and tools that allow services to be provided easily and robustly. The work emphasizes understanding of what makes future services useful, usable, and socially acceptable. The project creates experimental research prototypes of innovative services to understand users' needs and to stress network capabilities. It investigates advanced user interfaces and the tools for creating such interfaces to make a richer services environment accessible to ordinary residential and business users over the public network. And finally, the work of the project analyzes techniques (such as service control through high-level software, information browsing, and cryptographic security), and social or behavioral issues (such as privacy, collaborative work, and organizational acceptance) bearing on the success of future network services.

The knowledge generated by this project has impacts on BCC exchange businesses through several routes. It is passed to Information Networking Services and other areas of Bellcore, which work with the BCCs on network evolution. It is passed directly to the BCCs for their internal or other uses through demonstrations, talks, publications, and technology transfers of research prototypes, experimental services designs, and software. And it is passed to

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research and vendor communities, where it stimulates further research and development.

The benefits to the BCCs include increased efficiency in their internal operations, greater automation of subscriber-network interactions, higher utilization of network facilities, the development of new revenue streams as these and other services are provided over exchange carrier facilities, the ability to meet security and privacy concerns, and a leading role in the realization of an information society accessible to all through the public switched network.

The work has five thrusts: interpersonal communications, broadband services prototyping, information access and dissemination, network security, and human interfaces.

The work in interpersonal communications is focused on communication among individuals to strengthen their existing work activities and social relationships. Examples include distributed groups of collaborative workers, and family members seeking something closer to "being there". The project will investigate integrated multimedia communication, both real-time and messaging, with emphasis on visual elements. The project will further investigate broadband "unplanned" communications such as open or group-managed multimedia links, exemplified by a wide-aspect "VideoWindow" (augmented by four-channel audio, document sharing, and computer application-sharing capabilities), and a "Cruiser" system for casual voice and video interaction (augmented by document and application sharing) among the geographically distributed residents of a "virtual hallway".

Information networks research, with strong emphases on visual information and delivery via BISDN (Broadband Integrated Services Digital Network), will investigate techniques for both casually viewing information and more actively searching for it. In these studies, the intelligent, broadband network will be viewed as a vital component, facilitating access to a broad range of databases and media types. Attention will be focused on customized, sometimes adaptive, information filtering to reduce massive information flows otherwise placed on the network to manageable proportions (a central question for the evolving information society); but it will also be directed toward interfacing with heterogeneous information sources, technologies for multimedia composition and editing, media adaptations and conversions, and the study of "friendly" semantic, hierarchical, and advisory user interfaces facilitating user access and dynamic control.

Network security research is broadly directed toward the privacy and authentication of user traffic, the control of access to services and databases, and the protection of network functional elements in the more open network of the future. New efforts will be made on

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cryptographic and biometric user authentication systems and security architectures of an open network, and previous research continues on techniques for the production and exchange of secure, authenticated, multimedia electronic transactional documents (with digital signatures), and on speaker verification.

In general, the project's work program recognizes the business and research opportunities presented by providing communication services that bring people together with a compelling sense of "being there". The coming general availability of multimedia computing will increase the potential range of such services. One roadblock to the development of a broad base of computer-mediated telecommunications services is the lack of easy-to-use tools to construct them. The project's human interface research program will take advantage of these opportunities by examining and developing techniques to aid developers of multi-user and multimedia interfaces. In this conception, developers range from professional "programmers" to customers who have the ability to personalize their interfaces to communication services. While the focus of our "toolkits" research is to evolve software environments that facilitate the creation of multi-user applications, it is clear that technical problems impeding the development of high-quality single-user interfaces will be considered as part of the research program. The work will likely draw on object-oriented programming, behavioral science research, knowledge-based systems, graphical metaphors, and desk-top interactive video technology. The overarching goal is to understand the tools and techniques that will allow developers to build multi-user applications which will give people a sense of fidelity and presence through the use of media.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

In the second half of 1989, the project continued research on the major themes described above. Important examples of the Division's last six-month's accomplishments are given below:

Multimedia Interpersonal Communications

- U.S. patent (#4,890,314) covering the VideoWindow Teleconferencing system was granted on Dec. 26, 1989. Patent applications were filed for the "Laser-Pen", and "Video ViewGraph" interfaces for the VideoWindow, and an amended application was filed for a "Through-The-Screen Viewing" concept for Video-Phone terminals.

  Members of the Division continued evaluating users' interactions with each other over the VideoWindow. Results indicated that there are both usability (e.g., reciprocity of seeing and hearing) and group dynamic (e.g., transitions between public and private speech) issues that need to be addressed. Preliminary results were

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

documented in a book chapter that outlines our perspective on informal communications.

- Progress continued on implementing an audio and video communication system for casual interaction (Cruiser). The application software was completely redesigned, reimplementation of the application was started, and the prototype was ported to a pair of generic switches. These activities resulted in: (1) a more flexible and extensible application architecture, (2) a potentially faster Cruiser application, (3) improved functionality of the application, (4) a platform that gives us fine control over the behavior of the switch and associated peripherals, and (5) a system that will support up to 30 users, in place of the 15-user maximum available on the old platform. We published the Cruiser video tape, designed privacy mechanisms and new terminal equipment, and now plan an internal trial deployment in 1990. Finally, we established a collaboration with the Division 21450 (G. Herman, DvM) Touring Machine project to explore issues in system software support for advanced multimedia communications services.
- A new research initiative was initiated in the Division to investigate the feasibility and potential uses of enhancements to the normal mechanisms of electronic mail. This research attempts to go beyond the current state of the art in multimedia mail systems by permitting computational algorithms to be embedded in mail and bulletin board messages. It is hoped that by providing a powerful and general-purpose computational engine for use in mail software, a whole new generation of mail-based interactive services will become possible. The current research focuses on the key questions of portability and security, with the goal of producing a robust, portable, and secure research prototype in 1990.

Multimedia Communications Systems

- The analysis of Video-on-Demand systems was begun. One TM, "Analysis of the Generalized Information Providing System," provides an analytical platform and a second, "Models for Near-term Residential Video Services" (TM-TSV-014850) written jointly with Network Technology, describes near-term architectures for the delivery of video services. Work was begun in collaboration with Division 21480 (C. Judice, DvM) and Bell Northern Research on a novel "Store and Forward" video delivery concept.
- New research was initiated on several novel, hardware-based, visually-oriented interfaces to the broadband network. Work on video displays based on column-shutter/row-backlight techniques was begun. This research could lead to large, high-resolution displays suitable for enhanced VideoWindow and High Definition TV (HDTV) imaging. Research on a customer controlled viewing concept dubbed "SPHERE-O-VISION" was initiated. This concept will allow future broadband network subscribers to experience a virtually unimpeded, full look-around view of a remote location. Finally, work on a three-dimensional projection and imaging system was initiated. This system should ultimately allow real-time, three-

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

dimensional (volumetric) images to be transmitted and later viewed without special glasses. Near-term spinoffs of the technology will allow real depth display using conventional Computer Aided Design/Content Addressable Memory (CAD-CAM) workstation technologies.

Information Networks

- Project members completed a study of the visual quality of a version of a new 1.5 Mbit/sec full motion video compression algorithm developed by Division 21480 (C. Judice, DvM). Preliminary results had shown that it is possible to produce full motion entertainment video that can be transported at T1 rates with quality comparable to VHS (format used in 95% of home VCRs) recorded video. Subsequent work involving a thorough statistical analysis of the laboratory test results was completed and documented in TM-ARH-014569, "A Subjective Visual Quality Comparison of NTSC (National Television Standard Code), VHS, and Compressed DS1-Compatible Video." This work was reported at the *Fifth International Workshop on Telematics* in Denver, Colorado, and has been submitted for publication in a technical journal.
- Phase 1 of the Customized Electronic Information Delivery research prototype was completed. A research prototype multimedia formatter based on an extended SGML (Standard Generalized Markup Language) was written and tested as an Electronic Magazine on approximately 60 articles. Selection and display programs that take output from the formatter and present it as personalized "magazines" on an interactive terminal were written and demonstrated. Work on this phase was documented in TM-ARH-014704, "An Overview of the Electronic Magazine Project," and was presented at the Electronic Imaging '89 Conference in Boston, Mass. Work began on phase 2, incorporating digitized audio, a more graphical user interface, and a more sophisticated network delivery model in the prototype. We also began looking at the use of the Customized Electronic Information Delivery technology for in-house corporate information delivery systems.

Network Security

- A significant effort has been devoted to understanding the privacy implications of Caller-ID, which resulted in TM ARH-015905. This TM presents research supporting the principle that callees' rights to know who is using their time and equipment takes precedence over callers' rights to anonymity. It finds that both technology and privacy are dynamic, rather than fixed, concepts; simply because a technology offering convenience (the telephone) used to favor the privacy preferences of callers over callees, does not mean that the status quo should remain when the technology becomes available to reduce the privacy imbalance. The TM also delves into social norms and practices to ascertain prevailing American values vis-a-vis placing phone calls and examines the argument that Caller-ID will take away privacy rights. The TM concludes that Caller-ID

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accomplishes the opposite by removing caller anonymity, something that was a by-product of prior network design rather than a secrecy that our culture agreed should inhere in phone calls in the first place. There are also recommendations that certain safeguards be present in Caller-ID implementations.

We also reviewed research on psychology of memory, with the intent of understanding how the limitations of human memory affect the utility of the Caller-ID service. Our conclusion that, without mechanical assistance, people will often not be able to identify their callers from the caller's telephone number provided by Caller-ID, has implications for privacy policy and network services planning.

- Fast, secure methods of encryption and message authentication exist, provided that the parties first share a secret cryptographic key. Thus, key distribution is often the bottleneck of a secure multi-user communications system. We presented the work previously reported on a new, efficient key distribution system that authenticates the parties and creates dynamic session keys at Crypto'89, and then we built and demonstrated a working prototype of this system. Our efforts to make this prototype run faster led to the discovery of new algorithms for multiple precision integer arithmetic that are better than the previously existing ones for the 500-1000 bit numbers needed to achieve good security (TM-ARH-015023).
- Biometric methods of user identification can provide an important security primitive, especially when combined with sufficiently powerful smart cards and passwords or personal identification numbers. Our U.S. patent #4,827,518, "Speaker Verification System using Integrated Circuit Cards," generated numerous inquiries into this technology; and we continued to support the efforts of several BCCs to apply either smart card or speaker identity verification methods. In collaboration with Division 24110 (J. LaBanca, DvM), TM-TAP-105096, "Survey of Biometric Security Systems," and, in collaboration with Divisions 21360 (P. Shumate, DvM) and 21480 (C. Judice, DvM), TM-ARH-014515, "Field-Accessible Information and Speaker-Identity Verification: A Research Strategy" were issued.

Human-Computer Systems

- We completed version 1.0 of the MEL toolkit for multi-user graphical interface development. In addition, several small test and demonstration interfaces have been created to stress MEL's implementation of the basic object-oriented and constraint technologies.
- We completed a robust and usable version of SHADOWS, an application independent shared X window system. The SHADOWS system has been transferred to Division 27130 (H. Rubin, DvM) in Network Technology. TM-ARH-015522 was issued, and an extended, journal-length manuscript has been drafted which details the implications of shared windows applications for virtual terminal definitions.

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

- Work was initiated on AMES (Active Media Editing System). AMES is intended to be a multimedia composition tool. The goal is to build editing tools that gain information from the structure of the media they manipulate. Text processing tools have concepts of paragraph, chapter, list, etc., woven in to the fabric of the system. This is not true of time-dependent media like video, where the level of control stops at fast forward and freeze frame. The goal is to use AMES as a platform to understand communication-enabling tools for time-based media. A tool like AMES will make services like the Customized Electronic Information Delivery easier to create.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as communications terminals interfaces, behavioral science, multimedia applications, and user interfaces. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Research on novel, hardware-based, visually-oriented human interfaces to broadband networks. This will include work on large-screen, high-resolution video displays.

Research and prototyping of video-on-demand delivery service architectures.

Research into techniques, control, protocols, supporting technologies, and interfaces for multimedia, multi-person, computer-supported services and applications.

Research into multimedia information composition, editing, classification, filtering, and display for different modes of access, and tradeoffs among communications, storage and processing resources.

Investigation of techniques and design of toolkits for the straightforward design of multimedia and multi-user interfaces to communication and information systems.

Cryptographic and biometric research on security for network systems and social sciences research on communications privacy.

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Project Name: MULTIMEDIA COMMUNICATIONS
Project No.: 621406

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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 06/86 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
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SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name: SPEECH AND IMAGE PROCESSING
Project No.: 621408

Bellcore Product Manager: A. BERGH
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This Project is a Component of the Bellcore Product: APPLIED RESEARCH

Significant Change Date: 08/31/90

PROJECT OVERVIEW:

This project continues to explore specifically targeted research activities in speech recognition, speech synthesis, and the representation and coding of still and full-motion images. Furthermore, the project has focused on a limited number of speech and image processing applications, with the objective of driving the technology research by having a thorough understanding of end-user requirements. For example, the work on building a prototype electronic bulletin board for images, called FAXBOARD, has demonstrated a need for document processing techniques to optionally encode and render mixed-mode images with text and gray tones. Although the work is primarily aimed at advancing relevant technologies to the advantage of Bellcore Client Companies, a significant benefit is derived from understanding the time frames and rough costs of implementing those technologies and their associated services.

It is, of course, well recognized by the Bellcore Client Companies that speech technology could allow their customers to have direct access to computers and information databases using their phones as simple and inexpensive input/output devices. However, speech recognition has failed to achieve the performance necessary to make this vision practical. Therefore, this project has focused on telephone company operations with special emphasis on their directory assistance service. For example, after recording and studying hundreds of transactions between directory assistance operators and their customers, it became clear that even a modest degree of speech compression could significantly reduce the cost of this service to Bellcore Client Companies and their customers. Our goal is to demonstrate increasingly sophisticated speech recognition and synthesis technology as it applies to automating the directory assistance service.

In addition to focusing on how existing services could benefit from speech technology, research has also been directed towards making new services such as Automated Customer Name and Address possible. Here, machine pronunciation of surnames is a basic requirement. Over the years, this project has refined the capabilities of demisyllable-based speech synthesis to the point where a research prototype, called ORATOR, has been completed and demonstrated in the context of such a new service. Behavioral experiments show this approach to be superior

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Project Name: SPEECH AND IMAGE PROCESSING

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PROJECT OVERVIEW: (CONT.)

in both intelligibility and naturalness when compared with known alternatives.

In the image processing area we have packaged a software prototype, called FIVE (Format Independent Visual Exchange), and have made it available to all Bellcore Client Companies. This image processing software allows non-experts to use the most sophisticated compression, scaling and rendering algorithms in achieving practical image communications among dissimilar terminals. As a result, an information gateway can be designed to provide compatible multimedia communications among a wider variety of end user terminals.

Responding to Bellcore Client Company interest in providing point-to-point High Definition TV (HDTV) transmission to their customers, this project has been researching digital techniques that deliver full quality HDTV below 150 Mbit/sec at reasonable cost. Using a technique which reduces information redundancy on each frame of video, this project has demonstrated the feasibility of such an objective. This work has had significant impact on the research community, which previously did not believe such an accomplishment was possible. As laboratory prototypes are replicated by the vendor community, Bellcore Client Companies will be able to work with their customers in developing transmission services that satisfy their needs.

As the networks evolve to full deployment of fiber-to-the-home, it will be possible to extend the HDTV service previously described to residential customers. However, the Bellcore Client Companies are very interested in near term opportunities in video that make use of their existing plant. Research has been successfully directed at compressing TV signals at less than the DS1 (Digital Signal - Level 1) transmission speed (1.5 Mbit/sec). Recently, this project has successfully demonstrated 1.0 Mbit/sec video that has been judged in behavioral experiments as being as good as or better than VHS (format used in 95% of home VCRs)/VCR (Video Cassette Recorder) quality. In addition, near compact disk (CD)-quality audio has been demonstrated at 256 Kbits/sec. These two results, achieved through computer simulation of algorithms, are very encouraging, thereby launching a new research direction which has been named DS1-TV. Critical to the question of whether HDTV and NTSC (National Television Standard Code) video signals can be transmitted at rates of interest to Bellcore Client Companies, is whether the cost is reasonable. This project addresses this issue by selectively examining the feasibility of implementing the critical components in VLSI (Very Large Scale Integrated) circuits. Using high level design tools, this project has shown that motion estimation and compensation, a critical technique required to achieve DS1-TV capability, can be implemented on a single silicon chip.

With a trained staff of electrical engineers, computer programmers, psychologists and linguists, this project continues to push the

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SPEECH AND IMAGE PROCESSING

Project No.:
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PROJECT OVERVIEW: (CONT.)

technological boundaries of the network. Results in image and speech processing are opening doors for new revenue possibilities and cost reductions in current operations.

In 2H89, Division 21480 delivered 13 conference papers, gave 15 technical talks, had 2 patents pending, and had 1 patent granted.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

Most significantly, researchers in Division 21480 have shown that full quality, HDTV full-motion images can be economically compressed to less than 120 Mbits/sec. Furthermore, an HDTV with quality comparable to the current 6-9 Mhz proposals being made to the FCC can be coded at 45 Mbits/sec. At the low end of the digital spectrum, we have shown that VCR quality TV can be compressed to 1.0 Mbit/sec with near CD-quality sound at 256 Kbits/sec. Furthermore, we have shown that a critical component, i.e., motion estimation and compensation, can be implemented on a single VLSI chip. Finally, we continue to support over 27 sites that have our image processing software package called FIVE (Format Independent Visual Exchange).

In the speech area, we have completed the first phase of packaging our demisyllable based synthesizer called ORATOR, and have begun to make it available to clients.

Professional Activities
- Organized 5th International Workshop on Telematics; 70 world experts in information technology met in Denver, Colorado (US WEST was local host) to discuss advances in teletext, videotex, teleconferencing, and multimedia communications. This meeting gave the Client Companies an opportunity to learn about new developments in information technology and standards related to their distribution over evolving networks.

Video Coding
- Submitted a proposal to the International Standards Organization/Moving Pictures Experts Group (ISO/MPEG) standards group regarding the compression of video programming at 1.0 - 1.3 Mbit/sec with VHS/VCR quality for entertainment sequences. This proposal ranked in the top 4 out of 16, is CCITT XV (International Consultative Committee on Telephone & Telegraph) compatible, can be coded in real time, and can be implemented in fewer than four Very Large Scale Integrated (VLSI) Application Specific Integrated Circuits (ASICs). With evolving Asychronous Digital Subscriber (ADSL) technology that could transmit 1.5 Mbit/sec on a single twisted pair along with POTS (Plain Old Telephone Service), this work opens up an opportunity for the Client Companies to offer an

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Project Name:
SPEECH AND IMAGE PROCESSING

Project No.:
621408

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

early B-ISDN video service to residences. This work was demonstrated at the Naples, Florida, Network Planning Conference. (TM ARH-015076) and (TM ARH-014981)

Video Coding

- o Developed a new pre and post processing technique for DS1-TV images which originally come from a 24 frame per second source such as movie film. The technique restores the original 24 fps image enabling processing to occur on the original image, not the derived 30 fps image available on tapes and video discs. This technique significantly improves the quality of realistic, entertainment video sequences that have been coded with the Bellcore DS1-TV algorithm.
- o Developed new techniques for controlling the rate buffer of an HDTV subband/DCT (Discrete Cosine Transform) digital video coder. The technique keeps the bit rate within a predetermined range around 130 Mbit/sec by varying the amount of prefiltering (softening the image when appropriate) and subband coefficient quantization step size. Having a workable rate buffer technique is necessary for the operation of coders on circuit switched networks. This work was presented at the International Conference on Communications (ICC)/Supercom 90. (TM ARH-015267)

Image Communications

- o Developed and now ready for technology transfer, FAXBOARD multimedia electronic bulletin board. This system allows facsimile and other images to be posted on public bulletin boards implemented on graphic workstations running X-windows and interconnected over Ethernet. This facility could be installed in client R&D groups to improve informal communications with Bellcore researchers. FAXBOARD was demonstrated at the Naples, Florida Network Planning Conference. (TM ARH-014797)
  - o Two new capabilities have been added to Bellcore's FIVE software package. First, the recently agreed upon still image compression, i.e., International Standards Organization/Joint Picture Coding Experts Group (ISO/JPEG), has been included as an option. Secondly, Bellcore's neural net-based Optical Character Recognition (OCR) technique has been incorporated. The FIVE software package has been made available to Client Companies and universities as a research tool for experimenting with image communication services. (TM ARH-015998)

Video Systems

- o Completed a study of alternative architectures for delivering DS1-TV quality video-on-demand service over existing copper networks using High-Bit rate Digital Signal - Level 1 (DSL) and fiber-to-the-curb technologies. The study demonstrated the sensitivity of costs to the grade of service offered, and suggests marginal profitability if the video codec and subscriber line channel coders can be built for under a combined

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Project Name:
SPEECH AND IMAGE PROCESSING

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

cost of $800 - $1000 per subscriber. (TM TSV-014850)

Speech Processing System
- o Completed a concept demonstration of the technology to compress customer queries to a directory assistance operator, thereby reducing the operator holding time by 1 - 2 seconds. This demonstration forms the foundation of our Speech Processing System, a PC-based speech technology platform which will be used as a vehicle to move our speech technology into operator service applications.

Speech Synthesis
- o Completed Orator 1.0 speech synthesizer optimized for name pronunciation. Bellcore's demisyllable based synthesizer has been packaged and is available for Client Company use. Orator has been improved over earlier versions by having better duration roles for consonants, new mechanisms for assigning phrasal stress and handling hyphenated words and names, and improved inflections. Orator is particularly well suited for applications such as Calling Party ID announcement and Automated Customer Name and Address Service (inverse Directory Assistance) (TM ARH-012864, TM ARH-010405)

Speaker Identity Verification
- o Completed study of template compression relevant for smart card application of speaker identity verification. This work extends Bellcore's effort in using speech as a tool for providing secure access to Client Company buildings and services. (TM ARH-015505)

Hidden Markov Model (HMM) Based Sub-Word Recognition
- o Developed Hidden Markov Model-based speech recognition algorithm and implemented it in software. This software system recognizes individual phonemes that are part of any speaker's continuous speech. This approach is a foundation for the development of a Bellcore speech recognizer. One of the first intended applications for this technology is city name recognition as another ingredient in reducing the cost of directory assistance services.

Speech Processing
- o We have developed a unifying framework for viewing all forms of distortion measures for speech recognition. This has led to a new metric that gives better recognition accuracies than previously recorded. This is applicable to all recognition techniques (TM ARH-01405)

Project Name:
SPEECH AND IMAGE PROCESSING

Project No.:
621408

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge based in such key areas as visually oriented communications, speech recognition, voice technologies, and video coding. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Work in speech recognition will focus on the neural network and Hidden Markow Model (HMM) approaches for solving large vocabulary, continuous speech. Advanced signal processing techniques will be used to prepare the speech for recognition. Attention will be directed at solving those problems in speech recognition with parameters relevant to automating the directory assistance service.

The demisyllable-based speech synthesizer, ORATOR, will be improved to allow for a broader spectrum of input text and more natural sounding output. Considerable effort will be directed at making ORATOR available to and useful for the Bellcore Client Companies.

A new efort on DS1-TV prototyping will give considerable attention to technology transfer and allow ideas, concepts, and algorithms in image coding to be realized in research prototype hardware for service experiments. Simulation studies at 1.5 - 10 Mbit/sec will be conducted to determine optimal coding methodologies for evolving packet networks.

The FAXBOARD Image Bulletin Board will be made available to clients to explore its usefulness as a technology to support "collaborative work at a distance".

Project Name: SPEECH AND IMAGE PROCESSING
Project No.: 621408

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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council: RESEARCH & NETWORK | Committee: APPLIED RESEARCH | Forum: NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type: INFRASTRUCTURE | Work Category: PREVIOUSLY FUND | MULTI-YEAR
Start Date: 06/86
Completion Date: 12/92
Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01
Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET   CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
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BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:
COMPUTER NETWORKING

Project No.:
621409

Bellcore Product Manager:
A. BERGH

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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
07/19/90

PROJECT OVERVIEW:

This project provides applied research in support of high-speed computer network systems. Work will concentrate on the research necessary to realize large scale, high-speed, packet switched networks. Work in this area includes research into devices necessary to build high-speed packet switches, the architectures necessary to build large networks from these devices, and the protocols necessary to derive high-speed data communications services from these networks. This project continually evolves to keep abreast of, and be one of the leaders in, these technological areas.

Work in this project can be divided into two focused thrusts: switch architecture and data communications. The switch architecture thrust has as a long-term goal the demonstration of crucial switching components necessary to construct the broadband network. One of our early accomplishments was getting packet switching technology acknowledged as the method of choice for implementing the broadband network. Thus, this work concentrates on the invention and demonstration of prototype systems to perform packet switching at rates of 150 Mbit/sec and above. Furthermore, these systems must be expandable to the scale necessary to provide broadband network services to hundreds of millions of customers.

The data communications thrust is focused on the realization of high-speed computer communications using broadband networks. The emphasis on data communications stems from the perception that data traffic, being poorly matched to the current telephone network architecture, will be an important early application of broadband network technology. Our long term goal here is to gain an understanding of the techniques necessary to implement broadband data services on the broadband network models we design. This requires fundamental advances in the design and implementation of computer communications protocols.

One significant effort, begun in 1989, is Project DAWN. DAWN is a research collaboration with MIT and the University of Pennsylvania to explore the protocol architectures necessary to achieve very-high-speed computer communications over broadband networks. It is part of the data communications thrust of this project.

This project also serves as the primary point of contact between

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COMPUTER NETWORKING

Project No.:
621409

PROJECT OVERVIEW: (CONT.)

Bellcore and the National Research and Education Network (NREN). NREN is best described as an informal collection of researchers and funders of research in computer networking. It involves representatives from industry, academia, and government. It is the goal of this group (which loosely includes hundreds of people, but as yet has no formal organization) to create a national network to be used by researchers across the country. The network would provide user access at speeds of at least 1 gigabit/sec.

As part of the early research phase of the NREN, a set of gigabit research testbeds have been funded by the National Science Foundation (NSF) and the Department of Defense Advanced Research Project Agency (DARPA). This project is heavily involved with the AURORA gigabit testbed, whose goal is the construction of experimental prototype broadband network connecting research laboratories in the Philadelphia-Boston corridor. This project is concerned with the construction of prototype broadband switches and high-speed computer protocols to be used in AURORA, and also coordinates NREN work being performed by three other Bellcore projects.

This project also manages and operates an internal Bellcore computer center which provides primary computing service to about 200 members of the Applied Research Area. We designed an internal Bellcore high-speed computer network, which now provides communications among about 1100 minicomputers and workstations inside Bellcore. We operate the connection between Bellcore's internal computer network and the NSFNET, a NSF-sponsored computer network connecting about 100,000 computers in the international research community. We also provide technical support and consulting on computer network security.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

A considerable amount of work in the division is directed at the goal of producing a demonstration prototype broadband packet switching fabric. We decided, about two years ago, that the so-called Batcher-banyan architecture would afford maximum performance and minimal complexity. This architecture consists of a Batcher network, which sorts packets based upon their destination address, and a banyan routing network, which expands the sorted list, and directs the packets to the proper output ports on the switch. Accomplishments over the past several years have proven the viability of various sub-assemblies of our experimental broadband packet switching fabric.

A broadband packet switching fabric can be thought of as the heart of a broadband packet switch. However, in order to construct a complete switch, one must augment the switch fabric with contention resolution circuitry. A packet switching fabric cannot allow more than a small

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

number of packets (often 1) to be simultaneously transmitted to the same output. Contention resolution is the process of detecting when too many packets are simultaneously heading for the same output. The contention resolution circuitry selects the packets that are to be allowed to exit the switch immediately, and then buffers the rest for later output.

We have invented a novel contention resolution mechanism for a broadband packet switch, which has the codename "Sunshine". The Sunshine switch experimental prototype (actually it is a whole family of related designs) uses combinations of known contention resolution mechanisms (such as recirculation, multiple banyans, or trunk grouping) to achieve extremely low packet loss rates. Two patents have been issued on the Sunshine architecture, and a technical talk is currently available upon request.

A new research effort was started during 1989, dealing with high-speed transport protocols. A transport protocol is typically used to ensure correctness in computer-to-computer communications, but the thrust of this work is to design a protocol that will serve integrated (data, voice, video) applications. It is intended that this work will build upon the results of the broadband switching thrust. The long-term goal of the transport protocol work is the construction of an experimental prototype transport protocol which will have throughput between 150 Mbit/sec and 1000 Mbit/sec. Some early accomplishments are mentioned in this section, and it is expected that this thrust will produce substantial results in the 1990-91 timeframe.

During this period (July 1989 through December 1989), we wrote 11 TMs, published 3 papers externally, presented 5 talks at technical meetings and external seminars, and applied for 2 patents.

Specific project accomplishments include:

Broadband Switching Technolgy

- We continue to make progress on the construction of an experimental prototype Sunshine packet switch. The design has been partitioned, and about 9 custom integrated circuits have been defined. Work on these circuits has begun, and is expected to continue for 18-24 months. See TM-ARH-014106 and TM-ARH-014132.
- A simplified Sunshine switch prototype has also been defined, which requires only 6 of the above mentioned custom integrated circuits. Several individual circuit accomplishments follow.
- An improved generation of broadband packet switch integrated circuit chips were implemented in 1.2 micron CMOS (Complementary Metal-Oxide Semiconductor, a common integrated circuit manufacturing process). These experimental prototype switching chips have 32 inputs and 32 outputs, and have been tested at 170 Mbit/sec, exceeding our goal of 155 Mbit/sec. These chips are documented in two technical memoranda, TM-ARH-014508 and TM-ARH-

Project Name: COMPUTER NETWORKING

Project No.: 621409

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

015040. This generation of chips incorporates improved clocking circuitry and bounded logic delays which make the chips more robust when used in demonstration prototype packet switching systems, such as Sunshine. This accomplishment is a 170 Mbit/sec Batcher sorting chip.

- A research prototype Batcher merge chip, one of the above mentioned broadband packets switch chips, useful in building switches larger than 32 inputs and outputs, was designed, fabricated, and tested at 170 Mbit/sec.
- An experimental prototype banyan routing chip, compatible with the previous two chips, was designed, fabricated, and tested at 170 Mbit/sec.
- A printed circuit board, consisting of the Batcher above referenced sorting chip, banyan routing chip and some support circuitry was constructed and tested at speeds of over 155 Mbit/sec. This board was delivered to Division 21410 (S. Weinstein, DvM) for incorporation into a larger experimental prototype system, which will be delivered to a Bellcore Client Company (BCC) for further research and testing.
- In order to build packet switches larger than the 32 lines which can be fabricated on a single chip today, a special package must be constructed. The packaging of high-speed electronics is just as important as the electronic design itself, and in the case of high-speed packet switch fabrics, some rather unique requirements were made on the package. Since the switch fabric is synchronous, with each packet moving though the switch at exactly the same speed as the other packets, it was important that a package be invented that minimized the variance in the wire lengths between adjacent chips. A research prototype 3-dimensional package for a 256-line Batcher-banyan switch fabric was implemented, and was shown to be capable of transmitting signals reliably at speeds up to 200 Mbit/sec, while keeping the maximum wire length to approximately 4 inches. To demonstrate the viability of this concept, a partial 3-D Batcher-banyan switch fabric has been constructed. A research prototype 64-line fabric, operating at 100 Mbit/sec per line, is now operational in our lab, with demonstrations available upon request. This is an ongoing project aimed at demonstrating a 256-line prototype unit operating at 150 Mbit/sec per line. This work was carried out jointly with Division 21370 (J. Berthold, DvM).
- We have continued our simulation and analysis of broadband networks. Two new technical memoranda in this area have been written (TM-ARH-014755 and TM-ARH-014841).
- Recirculation is a contention resolution method where one connects some of the inputs and outputs of a switch to a shared buffer pool. Packets which cannot exit the switch immediately, due to their designated output being busy, are directed to the shared buffer pool through these recirculation lines. Shared buffers are theoretically the best buffering technique, but are expensive to implement because switch bandwidth must be dedicated to them. We invented a method of directing packets which are to be recirculated

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

to the idle input lines, thus avoiding the dedication of switch inputs to the shared buffer pool. This has the effect of increasing switch efficiency considerably at loads under 100%. A patent was issued on this technique, and a TM was written (TM-ARH-014891).

- A research prototype CAM (Content Addressable Memory) integrated circuit chip having on-chip self-test and repair capabilities was implemented in 2 micron CMOS (Complementary Metal Oxide Semiconductor). This is a special purpose memory chip which is useful, among other things, for routing packets through a broadband packet switch at very high rates. Organized as 256 words of 64 bits each, this experimental chip, containing over 250 thousand transistors, is one of the largest devices ever built by Bellcore. A TM was issued (TM-ARH-014939).

Computer Communications

- We have set up a collaboration with MIT and the University of Pennsylvania (Penn) to perform research experiments in high-speed computer networks. This project is named DAWN, and is intended to be a 3-year collaborative research effort to explore high-speed computer communications issues including: protocols, host computer interfacing, and high-speed switching. Two 90 day sabbaticals (one at MIT, one at Penn) were completed by Applied Research managers. A number of detailed design review meetings were held between MIT and Bellcore.
- One of the ancillary problems associated with building experimental transport protocols at high-speeds is that most reasonably priced computers (i.e., workstations and personal computers) are incapable of generating or absorbing data at rates of 150 Mbit/sec and above. We have studied the architecture of these host computers, and have made some recommendations about the best architecture for high-speed network interfaces. These results are documented in two technical memoranda, TM-ARH-015265 and TM-ARH-015630.
- One of the principal tasks a transport protocol must accomplish is error control and correction. A comprehensive study of methods for error control has been performed and documented in TM-ARH-015146.
- The Data Communications Prototype (DCP), an experiment we had been working on during 1988-89 has been completed. DCP was an implementation of a Local Area Network to ATM (Asynchronous Transfer Mode) cell-like interface, basically a high-speed software fragmenter/reassembler. A final report is available in TM-ARH-015028.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as high-speed data

Project Name:
COMPUTER NETWORKING

Project No.:
621409

REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

communications, switching, high-speed protocols, and protocol applications. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

The work on broadband switching will be focused upon the construction of an experimental prototype broadband packet switch for use in the AURORA gigabit testbed connecting U. Penn, MIT, IBM and Bellcore. This prototype switch will build upon the experimental switch component work we have done over the last several years.

The work in collaboration with Project 621307 (J. Berthold, DvM) on the 3-D packet switch package will continue, with the aim of demonstrating that a 256-line packet switching fabric can be constructed. Research prototypes and crucial sub-assemblies commercially unavailable will be constructed. This packaging technology will be incorporated into our experimental prototype broadband network.

The work on data communications applications of broadband networks will be focused on the fundamental limitations of high-speed computer communications protocols. An attempt will be made to understand the nature of speed limitations of current protocols, and then to design and prototype experimental protocols that can execute at speeds at or above the 150 Mbit/sec range.

A small research effort on network management will be undertaken so that the management aspects of the broadband network might be better understood. This research will start with some experiments on existing computer networks, with results to be extended to broadband networks and services such as Switched Multi-megabit Data Services (SMDS).

A small reserch effort on computer network security has been started, and is expected to expand slightly. We will continue to supply consulting services to the rest of Bellcore and the BCCs on computer network security.

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Project Name:
COMPUTER NETWORKING

Project No.:
621409

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Bellcore Product Name:
APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 06/86 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2802
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3080
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:
PHOTONIC SCIENCE AND TECHNOLOGY

Project No.:
821101

Bellcore Product Manager:
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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

This project explores the potential of optical and optoelectronic technology to impact future information network design and control by providing new capabilities for switching, routing, multiplexing, and signal-processing.

This research has immediate impact in the inputs we provide for generic requirements (Technical Advisories (TAs) and Technical References (TRs)); on planning; on influencing the vendor community; and on assessing the state of technology development.

In the longer term, our work will influence and provide guidance for planning the evolution of future communications networks that will need greatly enhanced capabilities for handling large amounts of information in flexible and economical ways in order to carry the wide variety of services which are currently envisioned. Experimental high bit rate lightwave communications systems are currently being researched at Bellcore. The limitations to the capacity of these lightwave systems do not come from the capacity limitations of the optical fiber used for transmission. The limitations are imposed by the electronic parts of the system. In this project, we are exploring ways in which such limitations may be overcome by the use of optical and optoelectronic elements.

To fulfill our responsibility for supporting Bellcore research on lightwave networks and systems, we provide both information and experimental research prototype devices that are not otherwise available. Our work has four major thrusts:

- Research on optical physics, including research on the growth, fabrication, and optical properties of layered and small volume semiconductor structures. These structures will be important elements in future high performance optical and electronic devices that are one of the keys to successful implementation of photonic technology. Our recent accomplishments in this area include: the invention and first demonstration of a liftoff fabrication technique that will allow lasers and other photonic devices to be integrated with electronic circuits; and the development of an optical technique that can be used to control crystal growth for reduced cost and more reliable semiconductor devices.
- Research on ultrafast optics and optical signal-processing,

Project Name:
PHOTONIC SCIENCE AND TECHNOLOGY

Project No.:
821101

PROJECT OVERVIEW: (CONT.)

including optical switching, nonlinear optical phenomena, optical implementations of neural networks, and the generation, handling, and transmission of ultrashort time duration pulses. Short optical pulse technology is essential for the efficient utilization of the high-speed capabilities of optics. Optical signal-processing offers impressive capabilities for flexible information handling. Our recent accomplishments in this area include: fabrication of the world's largest integrated laser array with electronic addressing; demonstration of a compact, fast access time holographic memory; invention and demonstration of programmable optical pulse shaping and coding for ultrahigh capacity multiuser networks; and generation of the highest power ultrashort light pulses from a semiconductor diode laser.

- Research on optoelectronics, including research on methods of creating the structures needed for low-cost, high performance lasers and amplifiers, and the integration of optical and electronic components on the same chip. It is widely believed that one of the keys to successful applications of photonic technology will be the availability of economical and efficient optoelectronic components, and the ability to integrate optical and electronic components on the same chip. Our recent accomplishments include: the design and fabrication of a novel angle-facet semiconductor amplifier; the fabrication of broadly-tunable narrow linewidth semiconductor lasers; and the demonstration of a record high-speed laser transmitter optoelectronic integrated circuit. A number of research prototype laser and amplifier devices that are not available commercially have been supplied to other projects in Bellcore for lightwave systems research studies.
- Research on photonic components, including research on the design and fabrication of experimental integrated optical components. Integrated optical components are essential elements in all current implementations of optical communications systems. Our recent accomplishments include: the invention and fabrication of a novel integrated optical switch device with digital switching characteristics; and the demonstration of a tunable, polarization-independent narrowband wavelength filter for wavelength multiplexing network applications. A number of research prototype integrated optical devices have been supplied to other projects at Bellcore for lightwave systems research studies.

The understanding, discovery, and invention of photonic components and techniques for the switching, routing and processing of high bit rate information will lead to a new generation of telecommunication networks with greatly enhanced capabilities to handle new high bandwidth services in flexible, efficient, reliable, and cost effective ways.

Project Name:
PHOTONIC SCIENCE AND TECHNOLOGY

Project No.:
821101

PAST YEAR RESEARCH ACCOMPLISHMENTS:

Technology Transfers

- We have continued to expand our device prototyping effort and have established numerous collaborative links with systems groups in other parts of the Applied Research Area. During this period, Division 21110 (project 821101) has fabricated and supplied for systems research studies to other projects at Bellcore: 10 research prototype lasers and amplifiers to several divisions; 2 novel digital integrated wavelength filters to Division 21360 (P. Shumate, DvM). All of these devices were experimental research prototypes that are not otherwise available.

  In order to derive maximum benefits from our research programs, our work has involved frequent outside contacts through some 6 industrial and 8 university research collaborations with institutions such as Heinrich Hertz Institute, Fujitsu, Hitachi, AT&T, Princeton University, MIT, David Sarnoff Labs, and the California Institute of Technology. These interactions include one member of this project as an Adjunct Professor at the University of Illinois, and one member as Adjunct Professor at Stevens Institute of Technology. There were 8 visiting scientists from leading institutions and universities such as Princeton University, the University of Illinois, the University of Tokyo, Tel Aviv University, and the Technical University of Munich. One member of this project was a visitor at Fujitsu in Japan under a collaborative research agreement during this period.

  During the second half of 1989, our work resulted in 82 Technical Memoranda, 88 talks (including 45 invited presentations at major technical conferences such as the Optcon Conference of the Optical Society of America and the Institute of Electrical and Electronics Engineers, Inc. (IEEE), The American Physical Society, The National Communications Forum, The Gordon Conference on Nonlinear Optics, The International Conference on Optical Communications (ICOC), and at major universities), and 8 new patent disclosures. Five patent applications were filed, and 8 patents were issued during this period.

  Because of space limitations, we list below only a sampling of the past six months' technical accomplishments.

Optoelectronic Integrated Circuit Components

- Optoelectronic integrated circuits (OEICs) which integrate optical devices such as lasers and photodiodes with electronic transistors to enhance circuit capabilities are key components for future wideband lightwave systems and optical networks. Two approaches were taken in our studies of OEIC feasibility: one is to integrate GaAs FETs integrate InGaAs Modulation-Doped Field Effect Transistors (MODFETs) with InP lasers. In the former case, we integrate InGaAs MODFETs with InP lasers, and we have

Project Name: PHOTONIC SCIENCE AND TECHNOLOGY

Project No.: 821101

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

also taken advantage of the material growth capabilities at Bellcore for the lattice mismatched growth of GaAs-on-InP (collaboration with Division 21130 (V. Keramidas, DvM)). The good material quality and the mature GaAs technology allow us to make a complex 2:1 multiplexer chip which contains 14 transistors, 6 diodes and 8 resistors, and has a speed of 10 Gbit/sec (collaboration with Division 21330 (N. Cheung, DvM)). The power consumption was 80 mW, only 20% of an equivalent silicon chip, which cannot be directly integrated with a laser. (See TM-ARH-013845 and TM-ARH-015557)

Our second approach is to make a modulation doped FET (MODFET) in InGaAs/AlInAs monolithically integrated with a GaInAsP distributed feedback (DFB) laser. The InGaAs MODFET provides high speed greater than that of GaAs FETs, and the DFB laser is needed at high bit rates to preserve the single frequency spectrum. This is the first attempt to integrate the most advanced electronic device and the DFB laser. The initial result showed that this experimental prototype chip can be operated at speeds as high as 11 Gbit/sec, the highest speed OEIC ever reported. (See TM-ARH-015747, and TM-ARH-014536) The high-speed test is made in collaboration with Division 21310 (P. Kaiser, DvM). This OEIC transmitter chip will be made available for high-speed transmission experiments in Division 21310 (P. Kaiser, DvM).

o Optoelectronics technology is based on III-V semiconducting materials, but they cannot be grown to the necessary degree of perfection except on high-cost III-V semiconducting substrates. We recently invented a method, called liftoff, that allows extremely thin electronic-grade layers to be separated from the substrates on which they were grown and re-mounted on other materials such as silicon chips and glass and lithium niobate waveguides. This technique has the potential to substantially reduce the cost of these components, and gives new flexibility in the design of optical circuits. We have succeeded in mounting InP/InGaAs photodiodes on sapphire, integrated GaAs metal-semiconductor-metal detectors on lithium niobate and glass waveguides, and GaAs transistors on silicon wafers. The InP/GaAs photodiode exhibited a high quantum efficiency (90%) and a large estimated bandwidth (13.5 GHz). This work has received publicity in Science, The New York Times, and The Wall Street Journal, among others. The technology has been licensed, and some royalties have been received. Two patents have issued, and two further disclosures are being considered. (See TM-ARH- 015124, TM-ARH-014023, and TM-ARH-014866)

Optical Switching

o To exploit the potential of optical devices for ultrafast switching beyond the range of electronics, we need new optical switch configurations. We have invented some types of ultrafast optical switches based on a new type of nonlinear laser beam propagation which occurs in planar waveguide structures. Under appropriate

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Project Name:
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821101

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

conditions, we are able to demonstrate that a specially shaped beam, called a spatial soliton, can propagate in a glass planar waveguide without significant distortion. (Conventional laser beams, which are not solitons, unavoidably spread out as they propagate in bulk media.) Our results constitute the first observation of spatial solitons in a solid state material. This work will be presented as an invited paper at the Conference on Lasers and Electro-Optics in 1990, and a patent has been issued (U.S. patent #4,856,860). (See TM-ARH-015352, TM-ARH-015676, TM-ARH-015971)

Semiconductor Lasers for Communications

- o Coherent lightwave systems are the optical analog of superheterodyne radio and microwave systems. The attributes of such coherent lightwave systems are presently being researched by Division 21310 (P. Kaiser, DvM). Single frequency, narrow linewidth, and wavelength tunable lasers are essential sources for the coherent lightwave system. Previously, we have reported the quarter-wave shifted distributed feedback lasers made by the liquid-phase epitaxy at Bellcore. These lasers exhibited stable single frequency with a linewidth of 3 MHz. (See TM-ARH-012347) We have also reported a multi-electrode distributed Bragg reflector (DBR) laser whose single frequency light output could be tuned electronically over a range of 1 terahertz. (See TM-ARH-013847, TM-ARH-014279, and TM-ARH-014608) In this reporting period, we have modified the wavelength tuning conditions by allowing both forward and reverse bias voltages on the tuning section, and the tuning range has almost doubled. (See TM-ARH-015529) Such wavelength tunable lasers not only have useful applications as the local oscillator in the coherent lightwave receivers, but also have potential applications in multi-wavelength packet switching which have been extensively researched by Bellcore, linkage to Division 21360 (P. Shumate, DvM). (See TM-ARH-013592, TM-ARH-013874, TM-ARH-013930, TM-ARH-014696)

Display Research

- o Progress in efficient large-area displays will impact new services which are likely to create increasing demands for higher bandwidth information networks. To gain some insight into the evolution of this technology, we have been studying a column-shutter row-backlight display which has potential for providing large-area, flat-panel displays capable of displaying full-motion video. The liquid-crystal technology necessary for the column shutters is almost available. To obtain efficient, high-brightness row backlights, a new type of row backlight based on "leaky light guides" excited by high-efficiency, high-brightness light emitting diodes (LEDs) was devised and demonstrated. An experimental display using this backlight was about 2.5x more efficient than commercial dc-plasma displays. A patent application is in preparation. (See TM-ARH-015047)

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PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

Ultrafast Optics

- Semiconductor diode lasers are compact, reliable sources of continuous wave or modulated light for use in current optical communications systems. Future high-speed systems, however, may require short optical pulses. We have investigated the use of semiconductor lasers and amplifiers to produce high peak power, ultrashort optical pulses; and we have succeeded in generating picosecond pulses with peak powers of several watts. The peak powers produced by our system are a factor of ten higher than those produced by previous semiconductor diode laser based systems. (This work was done in collaboration with SRI David Sarnoff Research Center. (See TM-ARH-015456 and TM-ARH-015675)

Optical Signal Processing

- Dense surface-emitting laser arrays may find important use in a variety of applications, such as optical signal processing, optical interconnection systems, and optical data storage. We have demonstrated a new method of fabricating dense, two-dimensional arrays of surface-emitting semiconductor lasers. Our method is based on an ion implantation process which simplifies the further processing steps required to implement integrated electronic addressing of the individual lasers in the array. We have used this approach to fabricate a 32 x 32 array of lasers which utilizes an electronic addressing scheme known as matrix addressing. This is the world's largest array of lasers with integrated electronic addressing. A patent application has been filed. (See TM-ARH-015559, TM-ARH-015748, and TM-ARH-015749)

  We have demonstrated that surface-emitting lasers can be used to read-out two-dimensional images stored in holograms. By turning on different lasers within the array, different images stored in the hologram, each corresponding to a page of 100,000 bits of information, can be retrieved. This work points the way to a compact, fast access time, holographic memory, which could potentially be used for optical data processing and distribution systems. A patent application on this work has been filed. (See TM-ARH-015083)

Optical Phenomena and Spectroscopy

- The control of the growth of semiconductor device materials and structures is crucial for reliable, low cost optical and electronic component technology. We have recently invented a double modulation extension of our noninvasive optical method of monitoring crystal growth in real time, which gives important real-time information about a semiconductor surface during growth. This invention also solves a 20-year problem of how to obtain chemical and structural information about a semiconductor surface without having to destroy the surface. Using this approach, we have established the behavior of several GaAs growth surfaces of interest for molecular beam

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821101

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

epitaxy. Theoretical calculations have also been performed to relate the observed optical structure to specific transitions involving Ga and As chemical bonds on the growth surface. This combination of experiment and theory allows us to track the Ga and As concentrations on these surfaces, leading the way to better control of growth processes. At last count, this project has generated 8 invited talks at major conferences in 1989 and 1990. A patent application on the original method has been filed. (See TM-ARH-014071, TM-ARH-014745, and TM-ARH-015406)

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as optical and solid-state science. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Research on optical physics including research on the growth, fabrication, and optical properties of layered and small volume semiconductor structures. Of particular interest are the surface and interface properties. These structures are expected to be key elements in the next generation of telecommunications components.

Research on ultrafast optics and optical signal processing including research on optical switching, nonlinear optical phenomena, optical and optoelectronic implementations of neural networks, and the generation, handling and transmission of ultrashort time duration laser pulses such as those required for very high bit rate optical fiber communications.

Research on optoelectronics including research on methods of creating the structures needed for low-cost, high performance lasers and amplifiers, surface-emitting laser arrays, and the integration of optical and electronic components on a single chip. Research prototype devices will be supplied for advanced systems research experiments.

Research on photonic components including research on the design and fabrication of integrated optical components. Research prototype components will be supplied for advanced systems research

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RESEARCH DIRECTIONS: (CONT.)

experiments.

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Project Name:
PHOTONIC SCIENCE AND TECHNOLOGY

Project No.:
821101

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Bellcore Product Name:
APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/88 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
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BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

Project Name:
ELECTRONIC SCIENCE AND TECHNOLOGY

Project No.:
821102

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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

The contributions of electronic science and technology research to device technologies critical for current telecommunications science are indisputable. Present research trends are toward systems exploiting higher speed, lower power, greater flexibility in network control, and increased use of optical components to provide for the networks and network services of the future.

Experience has shown that to sustain continuing systems evolution, a pattern of component technology discovery is required; discovery aimed at exploiting more complex and unique applications of materials and at the realization of smaller devices, consuming less power and capable of increased speed and more complex function. Also, as the network evolves toward greater use of optical technologies, with the advantages of high-bit-rate optical transmission now well established, advances in the performance of components integrating electronic and optical functions hold promise of an evolution toward increasing use of optical control in the network.

Thus the challenge today, in planning for future network needs, is to determine the correct mix of optics, electronics and integrated optoelectronic component technologies to take advantage of the broad bandwidth available with optical fiber, while achieving efficient, low cost, effective high-speed information distribution. This challenge is addressed at all levels in Applied Research (AR) projects, and the members of this project contribute by conducting research covering a wide range of topics in electronic science and technology.

This project's principal aim is to advance the understanding of the electronic properties of materials and devices which define and limit their potential impact on telecommunications science. A major goal is to contribute to maintaining the pace of discovery necessary to sustain the evolution of components required to achieve and anticipate advanced network capabilities. Presently, of particular importance are those components contributing to the evolution of efficient broad-bandwidth fiber transmission and high-speed switching.
In pursuit of these goals, the Division's research program has four major thrusts;

1. high-speed device research aimed at influencing the evolution of technologies important for future telecommunications applications, such as low power electrical components fabricated

Project Name:
ELECTRONIC SCIENCE AND TECHNOLOGY

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821102

PROJECT OVERVIEW: (CONT.)

using compound semiconductor materials, high-speed switches, low noise optical receivers and integrated optoelectronic devices; and, in collaboration with Bellcore systems researchers, provide prototype research devices designed to meet the need of experiments aimed at clarifying network evolution,

2. quantum structures research, investigating the science and fabrication of small structures aimed at contributing to the body of knowledge required to anticipate the impact on exchange networks of future generations of high performance devices, while at the same time, providing a Bellcore material processing resource for investigating such state-of-the-art devices for advanced systems experiments as distributed feedback (DFB) lasers and submicron transistors,
3. solid state physics research aimed at providing early access to a broad range of emerging research results, particularly in areas expected to contribute to our understanding of the evolution of electronic devices potentially important to telecommunications, and
4. material and device characterization research aimed at providing analytic support to a range of AR research programs by providing detailed information on material, and material structures, critical to understanding the influence of fundamental material properties on useful applications.

In addition to work done in our own laboratories, members of this project engage in a range of collaborative research activities involving university centers, national laboratories and other corporate research organizations. These collaborations are designed to enhance and extend our capabilities and often involve other AR organizations as well. The combined purpose is to secure a role in the world of science and technology for Bellcore and our client companies that provides early access to, and influence on, a broad range of emerging research results with impact on telecommunication science. Some major past achievements of the Division's research have been:

1. pioneering research on the electronic device applications of Indium Phosphide based semiconductor materials more typically used for optical components in fiber systems. This research is having significant impact on our understanding of how optoelectronic device technologies will impact future fiber systems,
2. advances in microfabrication technologies that have permitted the fabrication of some of the smallest engineered structures ever reported, work that has contributed to the realization of research prototype laser devices currently finding application in a number of AR advanced optical systems experiments,
3. the demonstration of unique techniques for investigating charge transport in semiconductor structures that has provided significant information on the design and understanding of the potential limits of advanced electronic devices for exchange and

Project Name: ELECTRONIC SCIENCE AND TECHNOLOGY

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PROJECT OVERVIEW: (CONT.)

exchange access networks, and

4. new insights into the material structure of high temperature superconductor materials that are contributing significantly to our understanding, and ultimately to our ability to exploit, this remarkable physical phenomenon.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

The following provides an update on work performed in Division 21120 (R. Leheny, DvM). This and other work have resulted in 109 Technical Memoranda issued during the period 2H89-1H90; also 5 patents were issued and 1 application was filed. This project's work continues to benefit directly from the materials and other support received from Divisions 21110 (P. Smith, DvM), 21130 (V. Keramidas, DvM) and 21140 (B. Reagor, J. Wernick, DvMs). In addition, we benefit from ongoing collaborations/linkages with Divisions 21310 (P. Kaiser, DvM) and 21330 (N. Cheung, DvM) in the area of high-speed optoelectronic devices and with Divisions 21310 (P. Kaiser, DvM) and 21370 (J. Berthold, DvM) in the area of high temperature superconducting materials. These linkages are forming the basis for the design and fabrication of state-of-the art research prototype components for use in systems experiments.

High Performance Transistors

The major thrust of our research in high performance transistors is to advance the application of Indium Phosphide based materials. One principal impact of this work will be to provide research prototype devices to systems researchers. This work relies on continued collaboration with Division 21130 (V. Keramidas, DvM).

o Present broadband fiber optic systems experiments and future optical signal processing systems research require access to transistor technologies capable of providing high gain and fast switching speeds. We are researching the performance improvements possible by decreasing the control electrode dimensions on InAlAs/InGaAs Field Effect Transistors (FET). This work has yielded transistors exhibiting record high transconductance (1150 milli-Siemens/mm of gate length) and very high output current drive (in excess of 1.0 Amperes/mm gate length) with cut-off frequencies approaching 200 Gigahertz.
o We are investigating delta doping techniques as a means to increase charge in Field Effect Transistor (FET) conducting channels to increase transconductance of these devices. This work has demonstrated that transistors incorporating delta doping exhibit enhanced characteristics.

Integrated Optoelectronic Devices

Project Name:
ELECTRONIC SCIENCE AND TECHNOLOGY

Project No.:
821102

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

A major focus for this work is aimed at the integration of electronic components, such as FETs and Heterojunction Bipolar Transistors (HBTs), with optical components, such as photodetectors, lasers and waveguides. Material support provided by Division 21130 (V. Keramidas, DvM) is critical to this work.

- o In March, 1989 the IEEE Laser and Electro-Optic Society (LEOS), and a number of government agencies sponsored a Workshop for the purpose of defining the current status and future prospects for OEIC technologies. Bellcore Researchers were major contributors to this conference.
- o Integration of detector-waveguide combinations is expected to allow enhanced on chip optical signal processing such as Wavelength Division Multiplexing (WDM). We are investigating photodetectors integrated with either Field Effect Transistors or waveguide structures.
- o For many applications, fully integrated photoreceivers are expected to provide a low-cost alternative to hybrid circuits and when integrated into arrays also will permit enhanced signal processing functions, for example WDM. We have demonstrated the monolithic integration of a complete high performance transimpedance preamplifier. This research prototype chip is currently being investigated with members of Division 21310 (P. Kaiser, DvM) for use in high-speed subsystem applications.
- o Monolithic integration of active optoelectronic components and waveguides offers a number of advantages but an alternative approach separates the problem of optimizing performance of disparate devices by taking advantage of the technique for etch removal of thin films (lift-off) demonstrated by Division 21110 (P. Smith, DvM) to transfer devices from the substrate.
- o A novel approach to laser diode design is based on vertical resonators that emit their output beam from the surface of the laser chip which make them interesting for integration with electronic components. These preliminary device results are already finding applications in Division 21110's (P. Smith, DvM) optical neural networks research.

Material and Device Processing Research

A broad range of device research programs within Lab 211, aimed at making available experimental prototype devices such as distributed feedback (DFB) lasers and high performance transistors require access to advanced material processing. Much of this work is done in collaboration with Divisions 21110 (P. Smith, DvM), 21130 (V. Keramidas, DvM) and Division 21140 (B. Reagor, DvM).

- o In a widely publicized collaboration with Division 21130 (V. Keramidas, DvM) and AT&T Bell Labs personnel, we have continued to research the material growth and processing required to achieve low threshold current operation of novel vertical emitting laser structures.
- o For optical signal processing and integrated optoelectronic

Project Name: ELECTRONIC SCIENCE AND TECHNOLOGY
Project No.: 821102

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

applications, low threshold current lasers provide a particular advantage. Thresholds as low as 0.35 milliamp have been demonstrated and further reductions to as low as 0.1 milliamp are predicted.

- Even further reduction of laser threshold requirements to the microampere level should be possible. We demonstrated 30% reduction in threshold current from 3.5 to 2.4 milliamps.
- The fabrication of structures in which electrons are confined in three dimensions is possible. We have demonstrated the smallest engineered three-dimensional structures; vertical semiconductor columns less than 30 atoms across.
- Advances in semiconductor material processing could have significant implications for telecommunications. One such advance exploits an anomaly of silicon oxidation in regions of high curvature to realize a technique for forming atomically sharp silicon needles.
- Fine line patterning of high Tc superconducting material is critical for many of the anticipated applications of these materials. We have demonstrated a new etchant for these materials which permits etching in a more controlled manner than is possible with alternative methods. A patent has been obtained on this process.

Electron Transport in Semiconductor Heterostructures

Specially prepared semiconductor heterostructures will form the basis for the next generation of transistor devices that are expected to contribute to maintaining the evolution of high performance electronic systems for telecommunications applications. We conduct research on electron transport in these material structures with the goal of establishing a knowledge base for potential future device technologies anticipated to be important in meeting these system needs. This work is done in collaboration with Division 21130 (V. Keramidas, DvM).

- Electron transport in very narrow semiconducting wire structures is expected to be important for the design of future transistor devices. Our studies are currently aimed at investigating the influence of the wave character of electrons in small structures.
- Investigations aimed at understanding and exploiting the potential for infra-red light emission due to electronic transitions between quantum states formed in the conduction band of superlattice structures have shown that conduction band to valence band recombination plays an important role. It has been found that as a result of efficient impact ionization, electrons can generate holes; and this process modifies the effective electric field in the superlattice. Further, this process gives rise to band-to-band light emission in an otherwise uni-polar structure, i.e., without a p-n junction.

High Temperature Superconductors

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Project Name:
ELECTRONIC SCIENCE AND TECHNOLOGY

Project No.:
821102

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

The major focus of this work is on elucidating the electronic properties of this new class of superconducting materials. At this time it would appear that they hold the potential for such uses as low loss power distribution within buildings, high-speed switching, high-speed interconnections on and between circuit boards, and novel electronic devices based on the unique properties of superconductivity in these materials.

- One application of high Tc superconducting materials exploits their low resistance for low loss, passive microwave devices such as high Q filters and compact delay lines. Bellcore investigations of the microwave properties of Yttrium Barrium Copper Oxide (YBaCuO) materials are generally recognized as leading the world effort in this area. Work aimed at realizing practical high Q filters has begun.
- Some applications of high Tc materials to high-speed switching with low power requirements await the demonstration of a junction technology. Further effort is required before practical prototype devices can be demonstrated.
- Investigations of the superconducting properties of high Tc materials in high magnetic fields, or at high current density, are centered on understanding the nature of the motion of elementary units of magnetic flux called fluxons. This work is expected to contribute to the development of a comprehensive theory for superconductivity in this class of materials.

Electro-Optic Properties of Conducting Polymers

We are investigating a class of organic semiconductors with interesting electro-optical properties, including very large non-linear optical response, known as conjugated polymers. Their potential practical applications for telecommunications include all-optical switching and low cost electro-optical components. This work is being done in collaboration with Divisions 21110 (P. Smith, DvM) and 21140 (B. Reagor, DvM).

- Reviews of recent Bellcore work related to the nonlinear optical properties of conducting polymers and realizing practical optical switching devices utilizing polymer materials were published.

Materials Characterization

Material characterization links material preparation and application by providing detailed information, often on an atomic scale, of structure and composition. Accomplishments in this area are often characterized by the insight they provide into properties critical to achieving the engineered material structures important to optoelectronic devices. Most of the accomplishments reported here are the result of collaborations with Division 21130 (V. Keramidas, DvM).

- Electron microscopy provides a means to examine materials with nearly atomic resolution allowing detailed studies of defects and related anomalies of growth pattern. With members of Divisions

Project Name:
ELECTRONIC SCIENCE AND TECHNOLOGY

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821102

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

21130 and 21140 (V. Keramidas, and B. Reagor, DvMs), in a series of investigations of high temperature superconducting materials prepared in a variety of of ways we have reported on various structural properties of high Tc materials. This work is critical to providing information necessary to improve the quality of films for future device applications.

o The kind of information obtainable by detailed electron microscopy is critical to achieving high yield, and consequently low cost, for high performance electronic circuits. Working in collaboration with Division 21310 (P. Kaiser, DvM), and as part of a research collaboration with Avantek, we have provided information important to demonstrating process problems in realizing Si-IC's operating at multi-gigabit rates.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as optical and solid state science and materials research. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

RESEARCH DIRECTIONS:

Continue research on the design and fabrication of research prototype high performance transistors based on compound semiconductor material such as InP/InGaAs and GaAs/AIGaAs and having potential for high capacity lightwave systems. Research on the capabilities of IC (Integrated Circuit) technologies based on InP/GaAs transistor technologies for low power, high-speed optoelectronic applications.

Continue research on the integration of electronics with optical devices (optoelectronic integration), in particular the combination of optical modulators and drive electronics, photodetectors with receiver electronics, and other combinations aimed at performing efficient generation, detection and switching of high-bit-rate optical signals.

Research the application of regrowth techniques, incorporating multiple growth steps in a manner commonly used in silicon device fabrication, to the fabrication of experimental integrated optoelectronic components using compound semiconductors, which could greatly facilitate the fabrication of complex device structures.

Project Name:
ELECTRONIC SCIENCE AND TECHNOLOGY

Project No.:
821102

RESEARCH DIRECTIONS: (CONT.)

Research to advance the technology of electron beam lithography and related material processing techniques, such as reactive ion etching for the fabrication of microstructures critical to the performance of forward looking electronic and optical devices.

Research the techniques for very high-resolution patterning of semiconductors and other materials aimed at establishing the limits for engineering material structures on a scale where the quantum nature of matter becomes important to determining optical and electrical properties.

Research the electrical properties of microstructures at very low temperatures and very high magnetic fields to identify the physical properties governing charge transport in the limit where the quantum nature of matter significantly influences classical behavior.

Research the application of analytical techniques such as Transmission Electron Microscopy, Secondary Ion Mass Spectroscopy, X-ray Scattering and Neutron Scattering to the investigation of material and device structures of interest for advanced telecommunications components such as novel transistors, lasers and other optoelectronic devices, engineering material structures, and new materials such as the high temperature superconductors.

Research the physical relationship between material structure and electronic performance, in particular the relationship between the detailed structure of layered materials and voltage-current relationships governing the passage of charge through them. These material structures are playing an increasingly more important role in modern optoelectronic devices.

Research the properties of non-standard materials such as organic semiconductors and the new high temperature superconductors, with the aim to identify physical properties important for potential telecommunications applications such as efficient non-linear optical properties or efficient high-speed signal transmission.

Research the use of submillimeter-wave spectroscopy in conjunction with intense magnetic fields to determine the properties of electrons in structured semiconductor materials which are expected to be important for future telecommunications devices.

Project Name: ELECTRONIC SCIENCE AND TECHNOLOGY
Project No.: 821102

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Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council: RESEARCH & NETWORK
Committee: APPLIED RESEARCH
Forum: NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type: INFRASTRUCTURE
Work Category: PREVIOUSLY FUND | MULTI-YEAR
Start Date: 01/88
Completion Date: 12/92
Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01
Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:
SNET
CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-808-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2802
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

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Project Name:
PHOTONIC AND ELECTRONIC MATERIALS

Project No.:
821103

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This Project is a Component of the Bellcore Product:
APPLIED RESEARCH

Significant Change Date:
08/30/90

PROJECT OVERVIEW:

This Project Profile details the work performed in project 821103 during this reporting period. As before, the research is aimed principally towards providing projects 821101 (P.W. Smith, DvM) and 821102 (R.F. Leheny, DvM), Photonic and Electronic Science and Technology Research respectively, with the materials they need, materials not commercially available but required for their research and for creation of experimental research prototypes to be incorporated in Bellcore's systems research projects. Optical components (lasers, detectors), electronic devices at higher speed operating with lower power (transistors, drivers) and optoelectronic integrated circuits are playing an increasingly important role in the evolving exchange network. All such devices are made with complex "manmade" materials. To understand the potential impact of these devices on network evolution, we strive to understand these materials and to continue to improve our ability to control their physical and optical properties down to atomic layer dimensions. The understanding obtained through systems experiments utilizing these new, high performance devices provides the fundamental knowledge base needed for the cost effective planning of exchange networks with enhanced network capabilities.

PAST YEAR RESEARCH ACCOMPLISHMENTS:

Semiconductor Materials Research

Surface Emitting Microlasers and Microlaser Arrays

o Vertically emitting lasers have great potential for telecommunications applications. They can be coupled much more efficiently into optical fibers than conventional side emitting lasers currently used. Materials made by the process of Molecular Beam Epitaxy (MBE) as a composite of over 800 individually controlled, ultrathin layers have state-of-the-art thickness control of 1% and materials composition tolerance of 0.5%. They are used to fabricate extremely small lasers and groups of lasers called laser arrays. These materials achievements lead to lasers with extremely low threshold current (1.5mA) (the minimum current at which the laser can operate), with high yields and high

Project Name:
PHOTONIC AND ELECTRONIC MATERIALS
Project No.:
821103

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

reproducibility. Low threshold currents are important because they reduce the overall operating power requirements. The experimental prototype arrays have about 2 million lasers on a square centimeter size chip, with each laser only 5 micrometers in diameter, the smallest lasers made in the world. Fabrication of the devices requires special patterning and etching processes which are carried out in collaboration with Division 21120 (R.F. Leheny, DvM). Testing is carried out in collaboration with Division 21110 (P.W. Smith, DvM). (TM-ARH-015083, TM-ARH-015084, TM-ARH-015118, TM-ARH-015130, TM-ARH-015220, TM-ARH-015435, TM-ARH-559)

Ultra-Thin Layers for Electronic and Optoelectronic Devices Lasers

- o Lasers whose turn on (threshold) current is low reduce the power requirements for operating the fiber network. By using Molecular Beam Epitaxy (MBE) to grow very thin layers (quantum wells) on substrates from which parts have been preferentially removed to generate grooves, record low threshold experimental prototype lasers were made which operate at currents of as low as 0.35 milliamp, the lowest value ever reported, (collaboration with Division 21110, P.W. Smith, DvM). Achievement of such low current operation is essential for efficient integration of electronic devices and optical devices, an important research direction for future low-cost reliable devices for fiber telecommunications. (TM-ARH-013422, TM-ARH-013988, TM-ARH-14843, TM-ARH-015459).

Transistors

- o Transistors are ubiquitous devices in every aspect of telecommunications. The higher their performance, the faster are the processes they perform. Research prototypes of high performance Field Effect Transistors (FETs) have been prepared by the crystal growth process of Molecular Beam Epitaxy (MBE) by including special atomic sheets of impurities (delta doped) in the conducting channels of the FETs to provide improved performance (collaboration with Division 21120, R.F. Leheny, DvM). (TM-ARH-013692, TM-ARH-014716).

Buried Metal Layers

- o Metallic layers are always used for contacts and as components of many devices. Stable metallic layers improve the reliability of devices and systems. Research has continued on the epitaxial growth by molecular beam epitaxy (MBE) of metal layers which can be buried between gallium arsenide semiconductor layers. Work in progress utilizing the metal nickel aluminum has now been extended to the metal cobalt aluminum, which has its atoms more closely spaced and nearer to the spacing in gallium arsenide (the mismatch in atomic spacing is 2.1% for the nickel compound, but only 1.2% for the cobalt compound). The intimate coupling of the growth of both metals and semiconductors has extremely important potential, since all present semiconductor optoelectronic devices require that metals be included for electrical contacting. This in-situ method

Project Name: PHOTONIC AND ELECTRONIC MATERIALS

Project No.: 821103

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

of metallization has the added advantage that the interface between metal and semiconductor is oxide free since the process is carried out in high vacuum. This leads to electrical contacts with lower resistances. We have continued studies of the electrical properties of the metal-semiconductor interfaces and have found that the metal-semiconductor interfaces make excellent diodes, which can in fact be enhanced by including thin layers of aluminum arsenide between the metal and gallium arsenide. (TM-ARH-014739, TM-ARH-014977, TM-ARH-015425, TM-ARH-014922)

Growth on Non-Planar Substrates

Lasers

o Lasers are very expensive (,500 each) because of very low fabrication yields and very complicated processing steps. Growth on non-planar gallium arsenide and indium phosphide substrates, where material was removed preferentially to create V-shaped grooves, was studied in order to reduce the processing steps and improve the yield in fabricating novel devices. By exploiting the dependence of the dopant (impurity) incorporation on the type of facet of the material on which it is deposited, experimental prototype long wavelength lasers of the type needed for fiber optic communications were grown in a single step, instead of three. This is possible because the impurities align themselves entirely different inside a V-groove than outside of it (collaboration with Div. 21110, P.W. Smith, DvM). This achievement is expected to lower considerably the cost of lasers and improve the yields (TM-ARH-015372).

Waveguides

o Waveguides when tapered in three dimensions make possible far better coupling between photodetectors or optical fibers and will have significant impact in incorporating optoelectronic circuits for fiber-in-the-loop. Growth of such waveguides on non-planar gallium arsenide (GaAs) substrates where part was preferentially removed to generate special dimension trenches, was studied and a technique was established by which prototype tapered waveguides were made (Collaboration with Div. 21110, P.W. Smith, DvM) (TM-ARH-014879).

AlInGaAs Lasers for Erbium doped Fiber Pumping

o The emergence of fiber amplifiers for use in the fiber-in-the-loop creates a need for solid state lasers to "pump" the fiber amplifiers. High quality aluminum indium gallium arsenide (AlInGaAs) layers were grown by organometallic chemical vapor deposition and used to fabricate experimental prototype lasers operating at 0.98 microns. Stripe lasers 25 microns wide emitted as much as 370 mw of power. Their turn on (threshold) currents, are comparable to that of conventional 1.3 micron indium gallium arsenide phosphide (InGaAsP) lasers (collaboration with Div. 21110, P.W. Smith, DvM). The layers from which the light originates are grown intentionally to be under strain. This built in materials

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Project Name: PHOTONIC AND ELECTRONIC MATERIALS

Project No. 821103

PAST YEAR RESEARCH ACCOMPLISHMENTS: (CONT.)

property allows adjustment of the lasing wavelength between 0.95 and 1.65 microns, a very desirable flexibility for fiberoptic communications (TM-ARH-015704).

Fiber Optical Materials Research
Fiber Amplifiers

o Fiber amplifiers are rapidly evolving as viable components for the implementation of fiber communications. We have investigated the effect of glass composition and pump wavelength on amplification gain of silica glass optical fibers with the intentionally introduced impurity, erbium. We have observed over 3 dB/mw gain at the pumping wavelength of 0.98 microns in a fiber designed for wide (1525 to 1560 nm) optical bandwidth. These fiber amplifiers have been used to demonstrate simultaneous gain of over 20 dB per channel, for a high density wavelength division multiplexed system (HD-WDM) using 16 lasers, with 2nm spacing and an overall span of 34 nm. This system experiment demonstrated the use of fiber amplifiers in the distribution network. The system provided simultaneous distribution of 100 FM TV channels with subcarrier multiplexing with 12 distributed feedback (DFB) lasers and six 622 Mbits/sec digital channels for data and/or HDTV channels. (Collaboration Divisions: 21110, P. W. Smith, DvM; 21310, P. Kaiser, DvM; 21410, S. Weinstein, DvM and 21360, P.W.Shumate, DvM.) (TM-ARH-015847, TM-ARH-014814, TM-ARH-014686, TM-ARH-016056)

Long-term Fiber Reliability

o Our work through the Electronics Industries Association (EIA)/ Telecommunications Industries Association (TIA) committee has resulted in the adoption of a fiber dynamic strength measurement test procedure as an industry wide standard. This will impact on the assurance of long-term fiber reliability in the exchange network. This test procedure will now be submitted to the international standards bodies such as The Consultative Committee of International Telephone and Telegraph (CCITT) and the International Electro Technical Commission (IEC) by the TIA for adoption.

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work of this Applied Research Project provides for the development of a leading edge knowledge base in such key areas as materials research. Emphasis is placed on applications to current and future needs in networks, services and operations. The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the Project.

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Project Name:
PHOTONIC AND ELECTRONIC MATERIALS

Project No.:
821103

RESEARCH DIRECTIONS:

Research will continue on the growth, by organometallic chemical vapor deposition techniques, of ultra thin layers of materials with abrupt interfaces and controlled physical, optical and electrical properties and of the utmost purity for devices and integrated circuits to be used in experimental system prototypes for fiber-in-the-loop.

Research will continue on the growth, by molecular beam epitaxy, of device structures on planar and non-planar substrates for surface emitting lasers, transistors, waveguides and other devices with techniques that will ultimately result in low cost devices for fiber-in-the-loop.

Research will continue on the growth of individually designed semiconductor structures having atomically thin crystal layers, to meet the needs of research programs within Bellcore that are exploring the evolution of new components technologies for the exchange network.

Laser evaporation techniques will be used to reproducibly deposit high temperature superconducting thin films.

Research in processing high temperature superconducting thin films has been initiated. The emphasis here will be on low temperature processing of application in high-speed electronic circuits.

Research will continue on new and modified fiber compositions for optically active fiber amplifiers and lasers. The intentional, controllable incorporation of impurities that enhance amplification and lasing performance in fibers will be studied.

Participation in the Electronic Industries Association (EIA) fiber coating committee will continue in order to provide input and leadership for the establishment of national optical fiber and cable standards.

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Project Name: PHOTONIC AND ELECTRONIC MATERIALS
Project No.: 821103

Bellcore Project Manager: M J BOWDEN
Tel. No.: (908) 758-3360

Bellcore Program Manager: A. BERGH
Tel. No.: (201) 829-4938

Bellcore Subject Matter Expert: V G KERAMIDAS
Tel. No.: (908) 758-3353

Bellcore Product Name: APPLIED RESEARCH

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
RESEARCH & NETWORK	APPLIED RESEARCH	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/88 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	A. SHADMAN	EXEC DIR - DATA NTWK TECH	708-806-8214
BA	Y	M. WEGLEITNER	EXEC DIR - TECH DEV	703-974-1890
BS	Y	D. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	E. THOMAS	CORP DIR - ADV TECH DEV	914-683-2071
PB	Y	D. HARRIS	EXEC DIR - ADVANCED TECH	415-823-3060
SW	Y	J. CARPENTER	AVP - TECH PLAN & DEV	314-235-1550
US	Y	L. HOUSE	DIR - SPONSORED RESCH	303-740-1570

Research Tax Credit Application: NO

F01A03Z 0005218

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1991 FINAL PROJECT OFFERING

Project Name: SWITCHED FRACTIONAL DS1 & SWITCHED DS1	Project No.: 1R3521
Bellcore Product Manager: G. J. LUCIANI	Tel. No.: (908) 758-2478
This Project is a Component of the Bellcore Product: SWITCHED DS1	
Significant Change Date: 08/20/90	

PROJECT OVERVIEW:

This project will produce generic requirements to support real-time, public circuit switched DS1 and fractional DS1 (SWIFT-DS1) service capabilities. The project will also explore preliminary generic requirements for higher rate switched service capabilities (e.g., DS3, SONET).

Technology advancements in the areas of low bit rate video CODECs, low cost Synchronous Optical NETwork (SONET) transmission equipment, and increasing data traffic has resulted in a growing market need for public switched, wideband services. A public switched DS1/fractional DS1 service capability allowing customers to set up and tear down 1.544 Mbit/s and fractional DS1 connections in real-time should be cost-effective, near-term solution that satisfies part of this market need. This service capability allows use of existing DS1 customer premises equipment without modification. SWIFT-DS1 will also be supported over ISDN Primary Rate Interfaces. (Note: that the ISDN and non-ISDN interface will be compatible.)

The formulation of generic requirements for switched DS1 service capabilities will promote a multi-vendor environment and allow several supporting technology platforms (e.g., n x 64 kbit/s switch fabrics, digital cross-connect based solutions, asynchronous transfer mode based solutions) to be used. Several vendors are currently developing real-time switched DS1 service capabilities for their products but without Bellcore generic requirements, their implementations will be incompatible. Initial vendor trials for the switched DS1 and fractional DS1 service capabilities are expected in late 1991.

DESCRIPTION OF 1991 WORK:

The focus of this project in 1991 will be to issue TR-TSY-001068 on the public switched DS1/fractional DS1 service capability.

- Produce high level service descriptions discussing the architectural and other planning issues associated with wideband, public switched services.
- Support interactions with the vendor community in the

Project Name:
SWITCHED FRACTIONAL DS1 & SWITCHED DS1

Project No.:
1R3521

DESCRIPTION OF 1991 WORK: (CONT.)

development of appropriate generic requirements.

- Support appropriate standards (i.e., T1S1) work.
- Define the user and interoffice interface specifications to support these services. This includes specification of appropriate Signalling System 7 (SS7) messages for interoffice applications and the specification of appropriate Plain Old Telephone Service (POTS) and Integrated Services Digital Network (ISDN) signaling at the customer interface.
- Develop appropriate generic switching requirements. This will include appropriate billing and operations requirements.

DELIVERABLES:

No: F50
Original: *Commitment Date:* 3Q91
TR-TSY-001088 on real time switched DS1/fractional DS1 service capability will be mailed to the industry from Bellcore by 9/30/91.

No: F51
Original: *Commitment Date:* 3Q91
The project plan for the Switched DS1/Fractional DS1 project will be delivered to designated client representatives from Bellcore by 9/30/91.

No: F52
Original: *Commitment Date:* 4Q91
Status reports on standards activities relevant to switched DS1/fractional DS1 will be delivered to designated client representatives by 6/30/91 and 12/31/91.

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1991 FINAL PROJECT OFFERING

Project Name: SWITCHED FRACTIONAL DS1 & SWITCHED DS1
Project No.: 1R3521

Bellcore Project Manager: G.R. RITCHIE
Tel. No.: (908) 758-5400

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: R. BALLART
Tel. No.: (908) 758-5445

Bellcore Product Name: SWITCHED DS1

This Project supports the following Major Product(s):

Council:	Committee:	Forum:
NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
MULTI CLIENT	NEWLY ESTABLISH	SINGLE-YEAR	Start Date: 01/91 Completion Date: 12/91 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 07
Firm Quote: YES

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	N	N/A	N/A	N/A
BA	Y	R. ALBERS	AVP - TECHNOLOGY PLANNING	703-974-3646
BS	Y	D. A. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	N	N/A	N/A	N/A
PB	N	N/A	N/A	N/A
SW	Y	J. CARPENTER	AVP - TECHNOLOGY PLANNING	314-235-1550
US	N	N/A	N/A	N/A

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name: AIN RELEASE 1 PLANNING & REQUIREMENTS	Project No.: 1R4111
Bellcore Product Manager: C. WILLCOCK	Tel. No.: (908) 758-2321

This Project is a Component of the Bellcore Product:
AIN RELEASE 1

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

Advanced Intelligent Network Release 1 (AIN R1) is defined as the set of network changes targeted for 1994 that evolve the Bellcore Client Companies' (BCCs') networks toward meeting AIN goals of programmability, multi-vendor environment, and standard interfaces. The R1 architecture will incorporate the attributes of the various AIN Release 0 architectures deployed in 1991 and 1992, increase their functionality, and bring the network a step closer to the Information Networking Architecture (INA) target.

The major benefit of this Project is that it provides the necessary planning and requirements for a service-independent, vendor-independent platform which will facilitate the deployment of new revenue-generating services in your company's network.

Key assumptions are that:

- Vendor products based on AIN R1 requirements need to be available in the 1994 time frame;
- AIN R1 requirements will be based on the AIN R1 Baseline Architecture and the AIN R1 Network and Operations Plan;
- Technical Advisories for AIN Switching Capabilities, SCP Node, Service Logic Execution Environment (SLEE), and the Application Layer Protocol will be released at the end of 1990 and will serve as the basis for the work on the Technical References covered by this Project.

DESCRIPTION OF 1991 WORK:

Bellcore will continue its work to develop generic requirements for AIN Network Elements (NEs) and Operations. Included in this Project is generic requirements work to produce the following:

- Definition of the AIN Switch Capabilities which are the features necessary for a switching system to recognize and handle calls that require AIN processing. These AIN Switch Capabilities include description of the AIN R1 call model, billing capabilities, as well

Project Name: AIN RELEASE 1 PLANNING & REQUIREMENTS

Project No.: 1R4111

DESCRIPTION OF 1991 WORK: (CONT.)

as impacts on switching system operations, performance, reliability, fault recovery, and traffic engineering.

- Formulation of switching system requirements which are specific to the signaling and interactions between a switch and a Service Control Point (SCP) or adjunct.

- Definition of the Service Logic Execution Environment (SLEE) common to adjunct and SCP applications for the support of AIN service logic. Billing, performance, fault recovery, and reliability impacts will also be considered.

- Formulation of Adjunct system requirements supporting AIN R1 functions and operations interfaces. Billing, performance, fault recovery, and reliability impacts will also be considered.

- Formulation of SCP Node requirements supporting AIN R1 functions and network, billing, and operations interfaces. Performance, fault recovery, and reliability impacts will also be considered.

- Formulation of the switching system, Intelligent Peripheral (IP), and Resource Control Execution Environment (RCEE) requirements which are necessary to specify the signaling and interactions between a switch and an IP.

- Further definition of the Service Logic Program (SLP) architecture which includes Administrative SLPs (ASLPs), Feature SLPS (FSLPS), and Operations SLPs (OSLPs), and refinement of the SLP Programmer Reference Manual.

- Formulation of methodology for managing AIN feature interactions (particular emphasis will be given to the creation and population of Feature Interaction Tables).

In addition, this Project provides the generic requirements definition for:

- Operations capabilities in NEs required by AIN R1 and for associated Operations Applications (e.g., memory administration, surveillance, testing, data collection, traffic management).

- R1 specific NE/Operations System interfaces (e.g., SCP/Memory Administration).

- R1 specific Operations System/Operations System interfaces (e.g., Service Negotiation and Management/Memory Administration).

Note that this work does not include requirements for the Service Negotiation and Management (SN&M) application-independent (i.e., platform) capabilities which are offered in Projects 923457 & 1R4126.

Project Name:
AIN RELEASE 1 PLANNING & REQUIREMENTS
Project No.:
1R4111

DESCRIPTION OF 1991 WORK: (CONT.)

It does, however, include work to incorporate SN&M data requirements into the Release 1 information model.

Additional AIN R1 planning activities in this Project include:

- Verification of the AIN R1 architecture across architectural elements so as to insure that services can be successfully built and supported.

- Ongoing requirements-focused interactions with potential vendors of AIN R1 products. This will include responding to written comments provided by vendors in reaction to AIN R1 Technical Advisories or Special Reports reporting to the BCCs on vendor comments, and on proposals for addressing those comments.

- Support for the AIN Billing Team and Automatic Message Accounting Technical Support Group.

- The examination of the performance of the AIN R1 architecture. Included in this effort will be:

  * The creation of an analytical model and simulator to study the delay and capacity of the Switch/Adjunct interface in a typical deployment scenario.

  * Switch capacity issues (including the investigation of the effect of the call model, triggers, and signaling interfaces).

  * The enhancement of the AIN Service Performance Analyzer (ASPA) which is a SLEE simulator tool developed to assist the AIN service designers in evaluating the performance impact of a new service on the SCP and Adjunct in terms of delay and throughput.

In addition, this Project contains business support activities which will provide the BCCs with economic, regulatory, and business information support for AIN R1.

- Perform Business Management function for AIN.

- Support the BCCs in their business analysis of AIN deployment. Examples of such support include generic economic and market analysis, development of tools for use by the BCCs in the performance of their own economic and business analysis of AIN services, identification of possible new services, and evaluation of associated regulatory and stakeholder issues.

- Assess cross-elastic effects of AIN services on each other, on existing services, and with respect to services offered by interexchange carriers and enhanced service providers and

Project Name: AIN RELEASE 1 PLANNING & REQUIREMENTS

Project No.: 1R4111

DESCRIPTION OF 1991 WORK: (CONT.)

customer premises equipment offered by equipment vendors.

- Analyze different deployment options under consideration by the BCCs to provide AIN services to 1A ESS customers.

- Obtain an understanding of various stakeholder and regulatory issues for representative AIN services. Seek issues resolution by working with appropriate client and stakeholder bodies.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 2Q91
Adjunct System Technical Advisory (TA): These requirements for AIN R1 will include identifications of adjunct functionality and adjunct interfaces to other network and operations systems. This TA will be ready for order and shipment by June 30, 1991.

No: 002
Original: *Commitment Date:* 3Q91
Switch/Adjunct Interface Technical Advisory (TA): These generic requirements will focus on the definition of the lower layer protocols to be used for the interface between the AIN R1 Adjunct and switching systems. This TA will be ready for order and shipment by September 30, 1991.

No: 003
Original: *Commitment Date:* 4Q91
AIN Release 1 Report: Provides an assessment of changes from the Technical Advisories (TAs) planned to be included in the Technical References (TRs) as a result of industry feedback. Covers the switching system; Service Logic Execution Environment (SLEE); switch/SLEE application layer protocol and Service Control Point (SCP) Node. The report will be available by Dec. 31, 1991; the TRs will be ready for order and shipment by June 30, 1992.

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Project Name: Project No.:
AIN RELEASE 1 PLANNING & REQUIREMENTS 1R4111

DELIVERABLES: (CONT.)

No: 004
Original: *Commitment Date:* 3Q91
AIN R1 Intelligent Peripheral (IP) and Switch Interface Generic Requirements Technical Advisory (TA): Defines the signaling and interface between an IP and an AIN R1 switching system. Descriptions of Resource Control Execution Environment (RCEE) functionality needed to define the interface will also be included. This TA will be ready for order and shipment by September 30, 1991.

No: 005
Original: *Commitment Date:* 1Q91
AIN R1 Operations Applications Generic Requirements Special Report (SR) Issue 1: Provides generic functional requirements for operations capabilities that are new for AIN R1. This BCC-proprietary SR will be ready for order and shipment by February 28, 1991.

No: 006
Original: *Commitment Date:* 3Q91
AIN R1 Specification of Messages at the Operations System (OS)/Network Element (NE) Interface Technical Advisory (TA): Presents generic requirements for messages between NEs and OSs to incorporate new operations capabilities required for AIN R1. This TA will be ready for order and shipment by September 30, 1991.

No: 007
Original: *Commitment Date:* 3Q91
AIN R1 Specification of Messages at the Operations System (OS)/Operations System Interface Special Report (SR) Issue 1: Describes generic requirements for messages between OSs required by new AIN R1 capabilities. These requirements will be ready for order and shipment by September 30, 1991.

No: 008
Original: *Commitment Date:* 4Q91
AIN R1 Operations Applications Generic Requirements Report: Will present a preliminary view of Issue 2 of the AIN Operations Applications Generic Requirements Special Report (SR). The report will be available by December 31, 1991; the generic requirements SR will be available for order and shipment by June 30, 1992.

Project Name: AIN RELEASE 1 PLANNING & REQUIREMENTS
Project No.: 1R4111

DELIVERABLES: (CONT.)

No: 009
Original: *Commitment Date:* 2Q91
Performance Analysis of Switch to Adjunct Interface: Presents results of a detailed study of the delay and throughput associated with the Switch/Adjunct interface. This deliverable will be ready for order and shipment by June 30, 1991.

No: 010
Original: *Commitment Date:* 4Q91
Capacity Planning and Analysis of the AIN R1 Architecture: Reports on sizing and capacity issues related to switches, Signaling Transfer Points (STPs), and Signaling links due to AIN R1 traffic. This deliverable will be ready for order and shipment by December 31, 1991.

No: 011
Original: *Commitment Date:* 4Q91
Enhancements to the AIN Service Performance Analyzer (ASPA): Will allow the Service Logic Execution Environment (SLEE) simulator tool (that was developed in 1990) to support analyses of a wider range of services. This deliverable will also provide for the maintenance of the simulator code. This deliverable will be ready for order and shipment by December 31, 1991.

No: 012
Original: *Commitment Date:* 4Q91
AIN R1 Service Logic Program (SLP) Report: Provides a preliminary view of the generic requirements covering SLP software architecture, SLP programming, and procedures for resolving Feature Interactions which will be included in the AIN R1 SLP Generic Requirements Technical Advisory (TA). The report will be available by December 31, 1991; the TA will be ready for order and shipment by March 31, 1992.

No: 013
Original: *Commitment Date:* 3Q91
Deliver document on the results of preliminary laboratory testing efforts for Data Communications Service Concepts. This activity will support (AIN via) hands-on analysis of service opportunities.

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Project Name: AIN RELEASE 1 PLANNING & REQUIREMENTS

Project No.: 1R4111

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1ONS2X

Provides To:

1R4121 923457 1R4127 1R4128

REASON FOR INFRASTRUCTURE CLASSIFICATION:

This Project provides the formulation and promulgation of generic requirements for network equipment and software which are made available through an open communication and interaction process to all potential vendors of new industry-wide network capabilities.

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1991 FINAL PROJECT OFFERING

Project Name: AIN RELEASE 1 PLANNING & REQUIREMENTS
Project No.: 1R4111

Bellcore Project Manager: N/A
Tel. No.: (000) 000-0000

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: N/A
Tel. No.: (000) 000-0000

Bellcore Product Name: AIN RELEASE 1

This Project supports the following Major Product(s):
AIN RELEASE 1

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Start Date: 01/91 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH. SERVICES	312-805-2500
BA	Y	R. ALBERS	AVP - TECH. PLANNING	703-974-8005
BS	Y	D. KETTLER	DIR. - SCIENCE & TECH.	404-529-2602
NX	Y	R. HELGESEN	MNG. DIR. - NTWK. PLNG.	914-683-2034
PB	Y	R. IRELAND	AVP - TECH. PLANNING	415-823-7600
SW	Y	J. CARPENTER	AVP - TECH. PLNG. & DEV.	314-235-1550
US	Y	J. CZAK	DIR. - NTWK. ARCH. & STDS	303-889-6409

Research Tax Credit Application:

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Project Name: SONET RELEASE 1.0 INFRASTRUCTURE	Project No.: 1W0111
Bellcore Product Manager: J. M. CLARK	Tel. No.: (908) 758-4585

This Project is a Component of the Bellcore Product:
SONET REL. 1.0

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

The Synchronous Optical NETwork (SONET) Release 1.0 Infrastructure project provides for the basic foundation and common work needed to support and move the SONET Release 1.0 Product forward. Primarily, the work in this project is essential to develop the Generic Requirements and Standards that will enable potential vendors to develop and produce equipment and systems that will meet the Bellcore Client Companies (BCCs) needs for SONET Release 1.0 compatible equipment, and to provide for the Bellcore capability to analyze these vendor products on behalf of the BCCs. The project also provides the common support elements such as economic analyses and Product/Project management efforts needed to support both this work, and further, more vendor product specific work contained within the elective projects 1W0171 through 1W0177.

SONET is a concept that extends the concept of a standardized digital hierarchy beyond the traditional DS0-DS3 electrical hierarchy in use throughout telecommunications, into the multi-megabit/second digital world of fiber optic transmission.

SONET was originally conceived in response to the proliferation of vendor specific, proprietary, fiber optic systems that began to enter the telecommunications networks of the BCCs in the mid-1980s. The idea of SONET is to define and implement a set of standards, protocols, and operating features that will eventually enable the BCCs to implement a true multi-vendor, intelligent, fiber optic transmission capability in their networks. This is expected to provide substantial cost savings to the BCCs by elimination of many currently required "back-to-back" network elements, the establishment of a true multi-vendor environment with its resulting competition, and eventually by providing for flexible network capabilities and services not possible with current asynchronous systems.

Bellcore, with the concurrence of the BCCs, initiated standards activities in 1985, leading to two ANSI standards, one on rates and formats, and the other on the optical interface, being approved in 1988. The concept was also accepted in the international community, with three CCITT Recommendations, consistent with the ANSI standards, being approved in 1988.

Bellcore has also worked extensively with the BCCs and the vendor community to develop a number of generic requirements for specific

Project Name: SONET RELEASE 1.0 INFRASTRUCTURE
Project No.: 1W0111

PROJECT OVERVIEW: (CONT.)

Network Elements. Many vendors have announced their intentions of providing SONET compatible equipment starting in the 1989-1991 time frame, with two major vendors announcing full SONET compatible product lines. Limited field trials of simple SONET systems are also either in process, or planned for 1990-91 by the BCCs.

Two Bellcore Products, SONET Release 1.0 and SONET Release 2.0, are designed to take the promise of SONET from the world of concept and design into the real world of operating networks. The SONET Release 1.0 Product concentrates on the short-term goal of implementing a basic multi-vendor synchronous optical transport capability in the form of point-to-point systems and simple tree networks, as a replacement for the current vendor specific asynchronous transport links in the BCC networks. This will enable the BCCs to procure SONET compatible systems that can later be enhanced to provide additional, more sophisticated network capabilities, rather than continuing to purchase current asynchronous equipment, which is incompatible with these future capabilities.

With this in mind, some of the major guiding principles of the Release 1.0 product are as follows:

Major Goal:

To drive the implementation of a basic, synchronous, optical transport backbone into the BCC networks in a cost-efficient and effective manner.

Architecture:

The SONET Release 1.0 product will support the implementation of SONET transport systems in point-to-point and simple tree (via the use of Add-Drop Multiplexer equipment) architectures.

Equipment Compatibility:

The SONET Release 1.0 product will work to define all foreseeable "hardware affecting" elements of equipment so that future upgrade to enhanced SONET capabilities can proceed with minimal retrofit penalties. (New additions and software upgrades to equipment would be required, but changeout or obsolescence of existing plant would be minimal, if any.)

Multi-Vendor Compatibility:

SONET Release 1.0 requirements will allow for basic transport of SONET payload between equipment of differing vendors, and provide for basic operational capabilities such as Protection Switching and Maintenance Signaling across vendor boundaries. (However, single ended operations and maintenance of a multi-vendor link is not

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Project Name:	Project No.:
SONET RELEASE 1.0 INFRASTRUCTURE	1W0111

PROJECT OVERVIEW: (CONT.)

possible under Release 1.0)

(NOTE: Additional costs for client specific training (e.g. Bellcore TEC), and any associated costs for planning or development of Bellcore Operations Systems that may be required to fully exploit the potentials of SONET are not included in this project, but rather would be contained within their respective programs.)

DESCRIPTION OF 1991 WORK:

1991 work in this project includes:

Product/Project Management:

This project includes the needed Product/Project Management effort needed to plan the SONET Release 1.0 effort, and ensure that resources devoted to the total product are used in the most efficient and effective manner possible.

Generic Requirements:

One of the major areas of concentration for this project in 1991 is the development and maintenance of Generic Requirements in the equipment, operations technology, and quality and reliability areas. These documents are used by equipment and OSS suppliers as a basis on which to design products that meet the BCC's technical and business needs. Bellcore participation in, and coordination with, Standards bodies is also an integral and essential element of this work. These Generic Requirements are then used in the Technical Analysis of vendor equipment as the standards against which the equipment being considered by the BCCs is analyzed.

The major thrust in 1991 will be the updating of established requirements to reflect the results of real world use and testing, to ensure that these documents accurately reflect the actual technical and operational aspects of equipment being purchased by the BCCs.

Laboratory Capabilities:

The second major area of concentration in 1991 will be the development of laboratory capabilities for the testing of vendor provided SONET Release 1.0 compatible equipment and OSSs. The necessary knowledge base, test equipment, software, and procedures must be provided to enable analysis to be performed (in the elective projects - 1W0171 through 1W0177) to ensure that the vendor equipment being considered for purchase by the BCCs in fact meets the requirements they have specified. Specific work in this area

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Project Name: Project No.:
SONET RELEASE 1.0 INFRASTRUCTURE 1W0111

DESCRIPTION OF 1991 WORK: (CONT.)

includes the development of a sophisticated test setup that can analyze the SONET transmission parameters of vendor equipment to ensure that they meet the necessary requirements to assure inter-working with other equipment. Another area is the development of methods/equipment to simulate signaling and OS messages to verify equipment function.

NOTE: Requirements development work related to Quality Surveillance are not provided under the SONET Release 1.0 product, but rather are provided as an element of the Bellcore Quality Surveillance Product, as these requirements are generic to all suppliers in general, and are not specific to SONET equipment.

DELIVERABLES:

No: J50
Original: *Commitment Date:* ONGO
Provide quarterly Product Progress Report on Product and Project Management efforts in Support of SONET Release 1.0. Report to include status of major deliverables, potential jeopardies, and action plans. Report to be mailed to NTAQS PSG & other designated client representatives on 4/30/91, 7/31/91, 10/31/91 & 1/30/92.

No: J51
Original: *Commitment Date:* 1291
Publish Technical Memorandum concerning possible SONET Release 1.0 applications architectures & the economics involved in each. Provide information on interactions with, & economies of integration with existing asynchronous transport systems. Mail to BCC/Bellcore SONET Planning Team by 12/31/91.

No: J52
Original: *Commitment Date:* 1291
Revise and Reissue TR-TSY-000253 (SONET Transport Systems - Common Requirements) based on results of first round of Technical Analysis and Bellcore/BCC/Vendor interactions and standards activities. Available for order and shipment to industry 12/31/91. Mail Status Reports to designated client representatives on 7/31/91 and 1/31/92.

Project Name: Project No.:
SONET RELEASE 1.0 INFRASTRUCTURE 1W0111

DELIVERABLES: (CONT.)

No: J53
Original: *Commitment Date:* ONGO
Revise and Reissue as required, enhanced versions of TR-233 (SONET DCS), TR-496 (SONET ADM), TR-872 (SONET Digital Switch Trunk Interface) and TR-917 (SONET Regenerator), based on results of Technical Analysis and Bellcore/BCC/Vendor interaction. Mail Status Reports on progress to designated client representatives on 7/31/91 and 1/31/92.

No: J54
Original: *Commitment Date:* 0791
Publish Technical Memorandum concerning option/feature set compatibilities of SONET Network Elements (NEs) (Release 1.0 capabilities) to aid BCCs in determining SONET options selection for multi-vendor links of SONET NEs. Mail to Transport Panel and BCC/Bellcore SONET Planning Team by 7/31/91.

No: J55
Original: *Commitment Date:* ONGO
Provide Bellcore participation in standards activities on SONET transport and operations interface (SONET Release 1.0 capabilities) issues to contribute to and influence standards that support BCC business needs. Mail Status Reports on progress to designated client representatives on 7/31/91 and 1/31/92.

No: J57
Original: *Commitment Date:* 1291
Publish Technical Memorandum on engineering design considerations, including additional draft requirements for optical parameters, to address dynamic laser effects and dispersion in SONET transmission systems operating above OC-12. Mail to Transport Panel & BCC/Bellcore SONET Planning Team for comments by 12/31/91.

No: J58
Original: *Commitment Date:* 0591
Publish TR-TSY-001042, providing Operations System/Network Element and Network Element/Network Element interface generic requirements (ASN.1/CMISE messages) for a core set of operations functions (alarm surveillance, performamce monitoring, protection switching, and provisioning driven memory administration.) Available for order & shipment to industry and mailed to N&OA and NTAQS PSGs by 5/31/91.

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Project Name: SONET RELEASE 1.0 INFRASTRUCTURE

Project No.: 1W0111

DELIVERABLES: (CONT.)

No: J59

Original: *Commitment Date:* 1291

Publish enhanced versions of TR-TSY-000832 and TR-TSY-000833, providing Operations System/Network Element interface generic requirements (TL1 messages) for memory administration and network maintenance. Available for order and shipment to industry and mailed to N&OA and NTAQS PSGs by 12/31/91.

No: J60

Original: *Commitment Date:* 1291

Publish Technical Memorandum on "Devise Characterization of Opto-electronic components, and effects on Physical Design & Reliability Issues, as precursor to incorporation of revised requirements in the appropriate documents. Mail to Transport Panel & BCC/Bellcore SONET Planning Team by 12/31/91.

No: J61

Original: *Commitment Date:* ONGO

Develop Technical Analysis Lab capability for testing of SONET Release 1.0 capability equipment, including development of "SONET Test Bed" to analyze SONET signals, Operations Technology capabilities for analysis of NE/OS & NE/OS interfaces, and required Quality & Reliability lab capabilities. Mail Status Report to Transport Panel & BCC/Bellcore SONET Planning Team by 12/31/91.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1W0211

Provides To:

1W0211 1W0171 1W0172 1W0173 1W0174 1W0175 1W0176 1W0177

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work elements in this project serve as the foundation for the

Project Name: SONET RELEASE 1.0 INFRASTRUCTURE
Project No.: 1W0111

REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

balance of the work in the SONET Release 1.0 Product. One of the primary outputs, Generic Requirements, are placed in the public domain in the form of Technical Advisories (TAs), Technical References (TRs), and Technical Requirements Industry Forums (TRIFs). These documents and forums are open to all members of industry. The laboratory capabilities are for development and maintenance of test equipment, procedures, and the knowledge base and skills needed to conduct product specific product analyses. These capabilities are then used by all clients who have any type of analysis conducted in the future. Network Architecture and Economic Analysis work must also be shared to achieve its full value. The Product/Project management activities provide an overall structure to the product, and ensure the proper coordination of the diverse elements and organizations.

The substantial benefits of this project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this project.

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1991 FINAL PROJECT OFFERING

Project Name: SONET RELEASE 1.0 INFRASTRUCTURE
Project No.: 1W0111

Bellcore Project Manager: P E WHITE
Tel. No.: (201) 829-4757

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: J M CLARK
Tel. No.: (908) 758-4585

Bellcore Product Name: SONET REL. 1.0

This Project supports the following Major Product(s):
SONET REL. 1.0

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	SINGLE-YEAR	Start Date: 01/91 Completion Date: 12/91 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	M. WESTERHOLD	SR DIR - NTWK SERVICES	312-605-2074
BA	Y	R. ALBERS	AVP - TECHNOLOGY PLNG	703-974-3646
BS	Y	D. A. KETTLER	AVP - SCIENCE & TECH	404-529-2602
NX	Y	R. H. HELGESEN	MANAGING DIRECTOR	914-287-2034
PB	Y	R. K. IRELAND	AVP - TECHNOLOGY PLNG	415-823-7600
SW	Y	J. CARPENTER	AVP - TECHNOLOGY PLNG	314-235-1550
US	Y	D. MC CULLOCH	DIRECTOR	303-896-6870

Research Tax Credit Application:

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Project Name:	Project No.:
SONET RELEASE 2.0 INFRASTRUCTURE	1W0211
Bellcore Product Manager:	Tel. No.:
J. M. CLARK	(908) 758-4585

This Project is a Component of the Bellcore Product:
SONET REL. 2.0

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

The Synchronous Optical NETwork (SONET) Release 2.0 Infrastructure project provides for the basic foundation and common work needed to support and move the SONET Release 2.0 Product forward. Primarily, the work in this project is essential to develop the Generic Requirements and Standards that will enable potential vendors to develop and produce equipment and systems that will meet the Bellcore Client Companies (BCCs) needs for SONET Release 2.0 compatible equipment, and to provide for the Bellcore capability to analyze these vendor products on behalf of the BCCs. The project also provides the common support elements such as economic analyses and Product/Project management efforts needed to support this work.

SONET, is a concept that extends the concept of the standardized digital hierarchy beyond the traditional DS0 - DS3 electrical hierarchy in use throughout telecommunications, into the multi-megabit/second digital world of fiber optic transmission.

SONET was originally conceived in response to the proliferation of vendor specific, proprietary, fiber optic systems that began to enter the telecommunications networks of the BCCs in the mid-1980s. The idea of SONET is to define and implement a set of standards, protocols, and operating features that will eventually enable the BCCs to implement a true multi-vendor, intelligent, fiber optic transmission capability in their networks. This is expected to provide substantial cost savings to the BCCs by elimination of many currently required "back-to-back" network elements, the establishment of a true multi-vendor environment with its resulting competition, and eventually by providing for flexible network capabilities and services not possible with current asynchronous systems.

Bellcore, with the concurrence of the BCCs, initiated standards activities in 1985, leading to two ANSI standards, one on rates and formats, and the other on the optical interface, being approved in 1988. The concept was also accepted in the international community, with three CCITT Recommendations, consistent with the ANSI standards, being approved in 1988.

Bellcore has also worked extensively with the BCCs and the vendor community to develop a number of generic requirements for specific Network Elements. Many vendors have announced their intentions of providing SONET compatible equipment starting in the 1989-1991 time

Project Name:
SONET RELEASE 2.0 INFRASTRUCTURE

Project No.:
1W0211

PROJECT OVERVIEW: (CONT.)

frame, with two major vendors announcing full SONET compatible product lines. Limited field trials of simple SONET systems are also either in process, or planned for 1990-91 by the BCCs.

Two Bellcore Products, SONET Release 1.0 and SONET Release 2.0, are designed to take the promise of SONET from the world of concept and design into the real world of operating networks. The SONET Release 2.0 Product is designed to develop the potential to evolve the point-to-point and simple tree transport network provided by SONET Release 1.0 into a flexible optical transport network in which network re-configuration and services can be provided quickly and remotely via Operational Support Systems (OSS). This can be accomplished via exploitation of the capabilities of the SONET Embedded Operations Channel (EOC). The EOC takes advantage of the huge bandwidth fiber optic links to build into the SONET concept and protocols the ability to carry large quantities of standardized operational information in order to provide the potential for remote provisioning, active performance monitoring, and remote network re-configuration

In 1990 and 1991, the SONET Release 2.0 Product will concentrate on the development of standards and Generic Requirements, as the messages, protocols, and OSS linkages provided by the EOC are defined and incorporated into Bellcore equipment and system Generic Requirements. Also, due to the major impact on Operations, Maintenance, Administration and Provisioning (OMA&P) systems, the emphasis on Operations Technology requirements work will be a larger element of the work in Release 2.0 than it was for Release 1.0.

In the 1992 and 1993 timeframe as vendor equipment deployment occurs, the complexion of the Release 2.0 Product will change. The effort on standards and requirements will level out or decline, and the work will transition to a stronger emphasis on Technical Analysis of vendor product and systems.

With this in mind, the scope, and some of the major guiding principles of the Release 2.0 product are as follows:

Major Goal:

To drive the implementation of a sophisticated, flexible, fiber optic transport infrastructure into the BCC networks in a cost efficient and effective manner.

Architecture:

The SONET Release 2.0 Product will support the transition from the simple point-to-point and tree architectures provided by Release 1.0 into flexible and survivable ring and mesh topologies.

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Project Name:
SONET RELEASE 2.0 INFRASTRUCTURE

Project No.:
1W0211

PROJECT OVERVIEW: (CONT.)

Multi-Vendor Compatibility:

SONET Release 2.0 will drive the creation of standards/ requirements for both equipment and operational aspects of SONET so that the BCCs can achieve a true multi-vendor environment on both the transmission and operational support planes.

Enhanced Transport Network Capabilities:

The SONET Relase 2.0 will examine the potential for enhanced network capabilities such as survivability, dynamic bandwidth allocation, and remote network configuration, and then define and drive for these capabilities to be standardized and incorporated in such a manner so as to preserve interchangability between differing vendors' equipment and systems.

DESCRIPTION OF 1991 WORK:

1991 Work in this project includes:

Product/Project Management:

This project includes the needed Product/Project Management effort needed to plan the SONET Release 2.0 effort, and ensure that resources devoted to the total product are used in the most efficient and effective manner possible.

Network Architecture/Economic Analysis:

This project includes Network/Economic analysis of the potential architectures possible under SONET Release 2.0, and how these architectures can contribute to the Information Networking vision, and provide new capabilities such as rapid provisioning, improved survivability and the ability to support new services.

Generic Requirements:

This area is the primary emphasis of the project in 1991. It includes the development and maintenance of Generic Requirements in the equipment, operations technology, and quality and reliability areas. These documents are used by equipment and OSS suppliers as a basis on which to design products that meet the BCCs' technical and business needs. Bellcore participation in, and coordination with, Standards bodies is also an integral and essential element of this work. Establishment of appropriate standards ensure that the BCCs' requirements and resulting networks are in step with

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Project Name:	Project No.:
SONET RELEASE 2.0 INFRASTRUCTURE	1W0211

DESCRIPTION OF 1991 WORK: (CONT.)

national and international directions, and enable them to reap the benefits of global economies realized by vendors. These requirements will also be used in later (post 1991) Technical Analysis of vendor equipment as the standards against which the equipment being considered by the BCCs is analyzed.

Laboratory Capabilities:

The project also provides for the development of laboratory capabilities for the testing of vendor provided SONET Release 2.0 compatible equipment and OSSs. The necessary knowledge base, test equipment, software, and procedures must be provided to enable analysis to be performed (equipment requiring analysis is expected to be available starting in early 1992) to ensure that the vendor equipment being considered for purchase by the BCCs in fact meets the requirements they have specified.

NOTE: Requirements development work related to Quality Surveillance are not provided under the SONET Release 2.0 product, but rather are provided as an element of the Bellcore Quality Surveillance Product, as these requirements are generic to all suppliers in general, and are not specific to SONET equipment.

DELIVERABLES:

No: K50
Original: *Commitment Date:* ONGO
Provide quarterly Product Progress Report on Product and Project Management efforts in Support of SONET Release 2.0. Report to include status of major deliverables, potential jeopardies, and action plans. Report to be mailed to NTAQS PSG & other designated client representatives on 4/30/91, 7/31/91 & 1/30/92.

No: K51
Original: *Commitment Date:* 1291
Develop a Network and Operations Plan. This plan will provide the outline for evolution of the BCC transport capability to a flexible, SONET based network with substantial network/operations synergy. Economic analysis of various options will also be included. Final Plan to be mailed to N&OA PSG and other designated client representatives by 12/31/91. Interim Status Report - 7/31/91.

Project Name: SONET RELEASE 2.0 INFRASTRUCTURE
Project No.: 1W0211

DELIVERABLES: (CONT.)

No: K52
Original: *Commitment Date:* 1291

Conduct a major study and analysis of Surviviability options and architectures available with SONET. The analysis will include: probability risk analysis of root causes, Network/Economic analysis of architecture options, and resulting technical implications. Publish as Technical Memorandum and mail to N&OA PSG, NTAQS PSG and BCC/Bellcore SONET Planning Team by 12/31/91. Interim Status Report - 7/31/91.

No: K53
Original: *Commitment Date:* 0691

Conduct analysis of compatibility issues affecting planning for Carrier-to-Carrier interface. Publish as Technical Memorandum (TM) and mail to N&OA PSG, NTAQS PSG, and BCC/Bellcore SONET Planning Team by 6/91.

No: K55
Original: *Commitment Date:* 1291

Develop necessary requirements and criteria to provide both equipment and operations requirements such as software download, LAN interconnections, enhanceded DCC security, etc. for SONET Release 2.0. Include these requirements in new releases of appropriate Technical References. Mail Status Reports on progress and results to designated client representatives on 7/31/91 & 1/31/92.

No: K57
Original: *Commitment Date:* 1291

Provide status report on Generic and Network Element specific documents updated as required to specify reliability/availibility requirements for SONET Network Elements. Issue status report to Transport Panel, Quality & Reliability Panel, and BCC/Bellcore SONET Planning Team on 7/31/91 1/30/92.

No: K58
Original: *Commitment Date:* ONGO

Provide on-going Bellcore participation in standards activities on SONET transport and operations interface (SONET Release 2.0 capabilities) issues to contribute to, and influence standards that support BCC business needs. Mail status reports on progress to designated client representatives on 7/31/91 and 1/31/92.

Project Name: SONET RELEASE 2.0 INFRASTRUCTURE
Project No.: 1W0211

DELIVERABLES: (CONT.)

No: K59
Original: *Commitment Date:* 1291
Publish Technical Advisory (TA) on Operations Systems/Network Element & Network Element/Network Element interface generic requirements (ASN.1 messages) for an enhanced set of operations functions. TA to be mailed to industry and N&OA PSG by 12/31/91.

No: K61
Original: *Commitment Date:* 0791
Publish a Technical Memorandum (TM) on "SONET Nested Protection Switching Criteria". This is a pre-cursor to standarization and documentation in a Technical Advisory in 1992. Mail TM to N&OA PSG, Transport Panel, & BCC/ Bellcore SONET Planning Team by 7/31/91.

No: K62
Original: *Commitment Date:* 0991
Issue Supplement 1 to TR-TSY-000496 (SONET ADM) to provide criteria for uni-directional, path protection switched, ring applications. This TR will be available for order and shipment to industry from Bellcore, and will be mailed to the N&OA PSG by 9/30/91.

No: K63
Original: *Commitment Date:* ONGO
Develop Technical Analysis lab capability for analysis of SONET Release 2.0 capability equipment. Mail Status Report to Transport Panel and BCC/ Bellcore SONET Planning Team by 12/31/91.

No: K64
Original: *Commitment Date:* 0391
Conduct a study of the economics and applications of Uni-directional vs. Bi-directional rings, as a tool for setting priorities for development of standards and requirements. Publish as Technical Memorandum (TM), and mail to N&OA PSG, NTAQS PSG, and BCC/Bellcore SONET Planning Team by 3/31/91.

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Project Name: SONET RELEASE 2.0 INFRASTRUCTURE

Project No.: 1W0211

DELIVERABLES: (CONT.)

No: K65

Original: *Commitment Date:* 0691

Publish a Technical Memorandum (TM) documenting SONET features and capabilities for use and reference by new services planners and the BCCs and Bellcore. Mail to N&OA PSG, NTAQS PSG, Transport Panel, and BCC/Bellcore SONET Planning Team by 6/30/91.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1W0111 10NS2X

Provides To:

1W0111

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work elements in this project serve as the foundation for the balance of the work in the SONET Release 2.0 Product. One of the primary outputs, Generic Requirements, are placed in the public domain in the form of Technical Advisories (TAs), Technical References (TRs), and Technical Requirements Industry Forums (TRIFs). These documents and forums are open to all members of industry. The laboratory capabilities are for development and maintenance of test equipment, procedures, and the knowledge base and skills needed to conduct product specific product analyses. These capabilities are then used by all clients who have any type of analysis conducted in the future. Network Architecture and Economic Analysis work must also be shared to achieve its full value. The Product/Project management activities provide an overall structure to the product, and ensure the proper coordination of the diverse elements and organizations.

The substantial benefits of this project accure to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this project.

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1991 FINAL PROJECT OFFERING

Project Name: SONET RELEASE 2.0 INFRASTRUCTURE
Project No.: 1W0211

Bellcore Project Manager: P E WHITE
Tel. No.: (201) 829-4757

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: J M CLARK
Tel. No.: (908) 758-4585

Bellcore Product Name: SONET REL. 2.0

This Project supports the following Major Product(s):
SONET REL. 2.0

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	SINGLE-YEAR	Start Date: 01/91 Completion Date: 12/91 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	M. WESTERHOLD	SR DIR - NETWORK SERVICES	312-605-2074
BA	Y	R. ALBERS	AVP - TECHNOLOGY PLANNING	703-974-3848
BS	Y	D. A. KETTLER	AVP - SCIENCE & TECH	404-529-2802
NX	Y	R. H. HELGENSEN	MANAGING DIRECTOR	914-287-2034
PB	Y	R. K. IRELAND	AVP - TECHNOLOGY PLANNING	415-823-7800
SW	Y	J. CARPENTER	APV - TECHNOLOGY PLANNING	314-235-1550
US	Y	D. MC CULLOCH	DIRECTOR	303-896-6870

Research Tax Credit Application:

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Project Name:
FITL REQUIREMENTS & ARCHITECTURE PLNG

Project No.:
1W1511

Bellcore Product Manager:
J. R. PALLADINO

Tel. No.:
(201) 829-4188

This Project is a Component of the Bellcore Product:
FITL

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

This project provides Generic Requirements, Standards Support, and Technical Analysis Capabilities in support of providing basic telecommunications services (existing tariffed services, such as POTS, voice frequency specials, basic rate ISDN, etc.) over fiber in the distribution plant. In addition, it provides for the development of a prospectus and corresponding assessment of the technology impact to support video transport and transport of future broadband services. This project consolidates and augments current 1990 efforts to address near term deployment of Fiber to the Curb (FTTC)/Fiber to the Home (FTTH) and is focused on accelerating the development of technical criteria necessary for successful BCC deployments of vendor products to meet both residential and small business needs using Fiber in the Loop (FITL).

Volume deployment is viewed as requiring available mechanized flow-through operations support (with minimal work around), and an evolution path to support the transport of video and broadband services. Although the Operations Systems (OS) work effort to assure OS support within the deployment time frame is not funded under this Network Segment project, the development of network element generic requirements and generic OS/NE interface requirements for operations are included.

DESCRIPTION OF 1991 WORK:

Bellcore will contribute to national and international standards supporting BCC interests in fiber cable/components, system applications, and quality and reliability. Contributions will focus on test methods, component and system parameter definitions, and technology implementations. Generic requirements documents will be developed or modified to reflect component and system level requirements for the use of fiber in the loop. Participation in the standards organizations and continued dialogue with the vendor community will expedite the requirements development process and help ensure the availability of equipment consistent with BCC deployment needs. Work will continue on developing and documenting local and centralized powering options associated with FTTC and FTTH deployment, as well as battery back-up technology and requirements. Network element generic requirements and generic OS/NE interface requirements

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Project Name: Project No.:
FITL REQUIREMENTS & ARCHITECTURE PLNG 1W1511

DESCRIPTION OF 1991 WORK: (CONT.)

for surveillance, testing, memory administration, network data collection, and network traffic management will be formulated for delivering existing telecommunications services on Fiber in the Loop.

Deployment guidelines to support the initial delivery of basic telecommunications services will be released and will include information on ways to upgrade the initial deployment to provide video transport and future broadband services. In addition, a prospectus will be developed assessing residential video transport opportunities. To support future migration of near-term deployed FITL to a target broadband network that may employ SONET/ATM, studies will be conducted to assess both network technologies and signaling capabilities necessary to support future services.

Loop transport system reliability and availability models will be developed to determine appropriate system/component downtime allocations to ensure that customer service availability objectives are met. These models and information on other reliability issues will be used to update or issue new generic requirements for systems/components, and the Reliability and Quality criteria specific to FITL systems.

Test methods and procedures will be developed to support contributions to standards organizations and to support technical analysis of FITL supplier products.

DELIVERABLES:

No: 001
Original: *Commitment Date:* ONGO
Quarterly status reports (4/91, 7/91, 10/91, 1/92) will be mailed to the Network and Operations Architecture Product Support Group (N&OA PSG) summarizing ongoing activities and contributions to National and International Standards in the areas of FITL systems, optical media and components for loop applications, and transport system and device quality and reliability.

No: 002
Original: *Commitment Date:* ONGO
Quarterly status reports (4/91, 7/91, 10/91, and 1/92) will be mailed to the N&OA PSG summarizing ongoing activities in issuing new and revised generic requirements documents on distribution fiber and cable, distribution and service terminal closures, optical branching devices, and source/detector modules supporting basic telecommunications services on fiber.

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Project Name: Project No.:
FITL REQUIREMENTS & ARCHITECTURE PLNG 1W1511

DELIVERABLES: (CONT.)

No: 003
Original: *Commitment Date:* 1291
Technical Reference TR-909 on FITL systems for delivery of basic telecommunications services on fiber will be mailed to N&OA PSG and will be available for ordering by clients and industry by 12/91. The TR will include requirements for powering for the ONU and reliability and quality requirements. The TR will also include requirements for generic operations functions and for the generic OS/NE interface.

No: 004
Original: *Commitment Date:* 1291
A Technical Advisory covering methodologies for optical and electrical in-service performance monitoring and maintenance of multichannel NTSC video transport will be mailed to the N&OA PSG and to industry by 12/91.

No: 005
Original: *Commitment Date:* 1291
A Technical Memorandum will be mailed to the N&OA PSG by 12/91 providing deployment guidelines for the delivery of basic telecommunications services over fiber in the loop, including upgrade considerations for video transport and future broadband service delivery. These guidelines will recommend the economically optimum means of deploying fiber in the loop in urban, suburban, and rural environments.

No: 006
Original: *Commitment Date:* 0991
A prospectus will be mailed to the N&OA PSG by 9/91 summarizing residential video transport opportunities.

No: 007
Original: *Commitment Date:* 0891
A Technical Memorandum will be mailed to the N&OA PSG by 8/91 assessing network technologies and required signaling capabilities to support the evolution of FITL systems to SONET/ATM, future broadband services, and switched digital video services.

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Project Name: FITL REQUIREMENTS & ARCHITECTURE PLNG
Project No.: 1W1511

DELIVERABLES: (CONT.)

No: 008
Original: *Commitment Date:* 1291
A status report will be mailed to the N&OA PSG by 12/91 summarizing activities leading to a Technical Advisory on signaling capabilities to support the evolution of FITL systems to SONET/ATM, future broadband services, and switched digital video services.

No: 009
Original: *Commitment Date:* ONGO
Status reports will be mailed to the N&OA PSG on 4/91, 7/91, 10/91, and 1/92 summarizing the development of new and enhanced requirements related to the reliability and quality of FITL systems and components, including equipment availability objectives, system qualification tests, and video transport.

No: 010
Original: *Commitment Date:* ONGO
Status reports will be mailed to the N&OA PSG on 4/91, 7/91, 10/91, and 1/92 summarizing the development of test methods and equipment necessary to support the technical analysis of FITL systems, optical fiber and cables, and passive and active optical components.

No: 011
Original: *Commitment Date:* ONGO
Status reports will be mailed to the N&OA PSG on 4/91, 7/91, 10/91, and 1/92 summarizing Product and Project Management activities, identifying coordination of work efforts among BCC Product Teams/Product Support Groups, Bellcore intersegment work coordination, and overall project status.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1ONS2X

Project Name: FITL REQUIREMENTS & ARCHITECTURE PLNG

Project No.: 1W1511

PROJECT FUNDING DEPENDENCIES: (CONT.)

Provides To:

1W1571 1W1572 1W1573 1W1574 1W1575 1W1576 1W1577

REASON FOR INFRASTRUCTURE CLASSIFICATION:

This project produces and supports deliverables called Generic Requirements that are placed in the public domain in the form of Technical Advisories, Technical References, and Technical Requirements Industry Forums. These documents and forums are available and are open to all members of industry. All Owner- Clients substantially benefit from the network capabilities and cost avoidances resulting from the new features and functions vendors of network equipment provide based on these deliverables.

The substantial benefits of this project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this project.

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1991 FINAL PROJECT OFFERING

Project Name: FITL REQUIREMENTS & ARCHITECTURE PLNG
Project No.: 1W1511

Bellcore Project Manager: D S BURPEE
Tel. No.: (201) 829-4062

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: J R PALLADINO
Tel. No.: (201) 829-4188

Bellcore Product Name: FITL

This Project supports the following Major Product(s):
FITL

Council:	Committee:	Forum:
RESEARCH & NETWORK	TECH. PROCURE. SUPT.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	SINGLE-YEAR	Start Date: 01/91 Completion Date: 12/91 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH. SVCS.	708-605-2500
BA	Y	R. ALBERS	AVP - TECH PLNG	703-974-8006
BS	Y	D. KETTLER	AVP. - SCI. & TECH.	404-529-8822
NX	Y	R. HELGESON	MNG. DIR. - NTWK. PLNG.	914-287-2034
PB	Y	T. EDRINGTON	AVP - SCI & TECH	415-823-2999
SW	Y	J. CARPENTER	AVP - TECH. PLNG. & DEV.	314-235-1550
US	Y	J. CZAK	DIR - NTWK ARCH & STDS	303-899-6409

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name: SMDS PHASE 2 PLNG & REQUIREMENTS
Project No.: 1R2112

Bellcore Product Manager: J. SHANTZ
Tel. No.: (908) 758-2181

This Project is a Component of the Bellcore Product: SMDS PHASE 2

Significant Change Date: 08/31/90

PROJECT OVERVIEW:

As a market-driven follow-through to the initial high speed data service initiative undertaken in SMDS Phase 1, it is necessary that SMDS be expanded to become a more uniform, consistent national service with much broader, more ubiquitous deployment than that of Phase 1. The primary goal for Phase 2 is to increase market presence and provide national connectivity. This is the time frame in which the BCCs can establish themselves as major players in the high speed data services market. SMDS Phase 2 is designed to support a broader service deployment and national service capabilities.

The major objectives of SMDS Phase 2 are:
o A multi-vendor switch environment;
o Interexchange Carrier access service;
o Fully mechanized operations;
o Customer Network Management (CNM).

For all of these objectives, 1991 is a key year for developing Generic Requirements so that vendors will have adequate time to build equipment for the targeted 4Q92 deployment date.

DESCRIPTION OF 1991 WORK:

The 1991 work effort to support Phase 1 SMDS will focus on the four major objectives of providing a multi-vendor switch environment; interexchange carrier access service for a national service capability; mechanized operations; and CNM.

The multi-vendor switching environment will be accomplished through the specification of an Interswitching System Interface (ISSI). Areas requiring work include network and protocol architecture and interface and operations technology requirements. These efforts will require working closely with network equipment vendors.

The effort toward a national service capability will include service planning, economic and market analysis, operations technology requirements, billing requirements and the specification of the Interexchange Carrier Interface (ICI). The national service capability will require extensive interactions between the BCCs and the industry, in particular interexchange carriers.

Project Name: SMDS PHASE 2 PLNG & REQUIREMENTS
Project No.: 1R2112

DESCRIPTION OF 1991 WORK: (CONT.)

Mechanized operations will be specified and developed based upon the experiences of the Phase 1 trials, customer studies on additional services, marketing and operations planning.

The development of CNM features requires market, service and operations planning in addition to their specification in Generic Requirements. These efforts will require working closely with the BCCs, their customers and CPE vendors.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 1Q91
As part of the NSTP Process, a Network and Operations Plan will be developed for Phase 2 SMDS and issued to designated client representatives.

No: 002
Original: *Commitment Date:* 1Q91
Issue to the Industry TA-1061 specifying the Operations Technology generic requirements for the Interexchange Carrier Interface (ICI) for Phase 2 SMDS. These requirements supplement the 4Q90 release of the ICI requirements.

No: 003
Original: *Commitment Date:* 2Q91
Issue to designated client representatives a SR on Revenue Accounting Office (RAO) Impacts of Exchange Access SMDS for Phase 2 SMDS.

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Project Name: SMDS PHASE 2 PLNG & REQUIREMENTS
Project No.: 1R2112

DELIVERABLES: (CONT.)

No: 004
Original: *Commitment Date:* 2Q91
Issue to designated client representatives a SR on the NSCG Feasibility Analysis on SMDS Phase 2 as a national service, to support a BCC National Planning Letter. Set guidelines to promote and introduce the service on a national basis. The analysis will address the issues identified in the SMDS National Service Prospectus; either resolving the issues or stating the position taken on the issue.

No: 005
Original: *Commitment Date:* 3Q91
Issue TA-1062 to the Industry specifying the initial set of Customer Network Management features, to be offered in conjunction with Phase 2 SMDS.

No: 006
Original: *Commitment Date:* 3Q91
Issue TA-1059 (Issue 2) to the Industry of the InterSwitching Interface (ISSI) generic requirements for Phase 2 SMDS. This issue will incorporate industry comments received on TA-1059 Issue 1.

No: 007
Original: *Commitment Date:* 4Q91
Issue TA-1060 (Issue 2) to the Industry of the Exchange Access SMDS requirements for Phase 2 SMDS.

No: 008
Original: *Commitment Date:* 3Q91
Deliver a document on the results of preliminary laboratory testing efforts for Data Communications Service Concepts. This activity will support SMDS via hands-on analysis of service opportunities.

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Project Name: SMDS PHASE 2 PLNG & REQUIREMENTS

Project No.: 1R2112

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

10NS2X

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The substantial benefits of this project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this project.

1991 FINAL PROJECT OFFERING

Project Name:
SMDS PHASE 2 PLNG & REQUIREMENTS
Project No.: **1R2112**

Bellcore Project Manager:
N/A
Tel. No.: **(000) 000-0000**

Bellcore Program Manager:
N/A
Tel. No.: **(N/A) -**

Bellcore Subject Matter Expert:
NA
Tel. No.: **(000) 000-0000**

Bellcore Product Name:
SMDS PHASE 2

This Project supports the following Major Product(s):
SMDS PHASE 2

Council:	Committee:	Forum:
RESEARCH & NETWORK	**NETWORK STAND. & ARCH.**	**NOT APPLICABLE**

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	**NEWLY ESTABLISH**	**MULTI-YEAR**	Start Date: **01/91** Completion Date: **12/92** Revised Comp Date: **/**

FUNDING ALLOCATION

Allocation Basis: **01**
Firm Quote: **NO**

Non Affiliate Participation in this Project allowed: **YES**

Non Affiliate Participants:
SNET **CBI**

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	**Y**	**D. LATTNER**	**AVP - TECH. SVCS.**	**312-605-2500**
BA	**Y**	**R. ALBERS**	**AVP - TECH. PLNG.**	**703-974-8805**
BS	**Y**	**D. KETTLER**	**AVP - SCI. & TECH.**	**404-529-2802**
NX	**Y**	**R. HELGESEN**	**MNG. DIR. NTWK. PLNG.**	**914-683-2034**
PB	**Y**	**R. IRELAND**	**AVP - TECH. PLNG.**	**415-823-7600**
SW	**Y**	**J. CARPENTER**	**AVP - TECH. PLNG. & DEV.**	**314-235-1550**
US	**Y**	**J. CZAK**	**DIR.- NTWK. ARCH. & STDS.**	**303-889-6409**

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name: BISDN PHASE 1 PLNG & REQUIREMENTS

Project No.: 1R3011

Bellcore Product Manager: J. SHANTZ

Tel. No.: (908) 758-2161

This Project is a Component of the Bellcore Product: BISDN PHASE 1

Significant Change Date: 08/31/90

PROJECT OVERVIEW:

Broadband Integrated Switched Digital Network (BISDN) is a long term network delivery sector target that can provide integrated transport and switching for many different information services with varying traffic characteristics, e.g., voice services, video services, high speed data services, multi-media services. Currently vendors and standards bodies are making rapid progress towards developing initial BISDN equipment and defining BISDN standards which will have long term implications for Bellcore Client Company (BCC) BISDNs. In order to move towards a standard long term BISDN in a cost effective manner (avoiding the costs of moving from initial vendor proprietary equipment deployment to a standard BISDN environment), initial BISDN deployment should be based on standards and/or requirements.

BISDN Phase 1 will provide integrated access for a core set of initial capabilities. These capabilities include: high speed (DS1, DS3, 155 mbps SONET) connectionless data applications (e.g., CAD/CAM, medical imaging) via SMDS, Variable Bit Rate (VBR) connection oriented data services, switched point to point video, videoteleconferencing, switched and semi-permanent constant bit rate applications (e.g., DS1, DS3, fractional DS1 and fractional DS3). Longer term BISDN planning work will be contained in the BISDN Phase 2 Planning project (INet), and additional Broadband services work will be worked in the Product Concepts and Opportunity Analysis product.

The 1991 BISDN Phase 1 product will be in the early portion of the Requirements, Development and Deployment stage of the Network Service and Technology Process. The project will focus on making economic use of Bellcore resources, in conjunction with standards bodies and vendors, to support a standard initial BISDN deployment in the 1994 -1995 time frame. In addition this project will provide network planning, operations technology and operations systems analyses needed to support an initial BISDN deployment.

DESCRIPTION OF 1991 WORK:

The 1991 work for BISDN Phase 1 has two main components. The first component is network and operations planning work for Phase 1 BISDN.

Project Name: Project No.:
BISDN PHASE 1 PLNG & REQUIREMENTS 1R3011

DESCRIPTION OF 1991 WORK: (CONT.)

The second component is generic requirements, standards contributions and industry interaction which involves working with vendors and industry standards bodies to ensure that initial BISDN equipment is standards based, to the extent possible. Included in this work is ongoing interaction with vendors, e.g., industry forums, BISDN RFIs, meetings with individual vendors.

The network architecture and operations planning work will be focused on analyzing the key architectural, operations, market, and regulatory aspects of BISDN Phase 1. An important part of this work will be the identification of Phase 1 BISDN users and the needs of these users, which will be used to define the network and operations functionality required to meet these needs. This work will lay the framework for subsequent generic requirements, and standards contributions.

The outputs of the generic requirements and standards work will be Technical Advisories and special reports on certain key aspects of BISDN protocol, BISDN interfaces, and BISDN network element operations functionality, as well as ongoing contributions to the CCITT and T1 standards groups. These two activities are complementary since standards body recommendations can provide the foundation for generic requirements.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 2Q91
Industry Forum on BISDN will be held by Bellcore. This TRIF like forum will provide an opportunity for direct industry interaction on initial BISDN deployment, e.g., 1990 BISDN Framework TAs, initial BISDN services.

No: 002
Original: *Commitment Date:* 2Q91
Framework TA (FA-TSY-001112) on ATM Protocol specification will be mailed to the industry from Bellcore on 6/30/91. This document will define functions and procedures for the ATM Layer within the BISND Protocol Reference model. Along with industry feedback, and standards progress on ATM this FTA will provide input to a 1992 TA.

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1991 FINAL PROJECT OFFERING

Project Name: BISDN PHASE 1 PLNG & REQUIREMENTS

Project No.: 1R3011

DELIVERABLES: (CONT.)

No: 003

Original: *Commitment Date:* 3Q91

BISDN Network and Operations Plan SR will be mailed to designated client representatives by 9/20/91. This SR will provide a network architecture for BISDN Phase 1 (and Phase 1 services), identify operations impacts of BISDN on OSs and NEs, and provide an allocation of operations functionality between OSs and NEs.

No: 004

Original: *Commitment Date:* 3Q91

Protocol Architecture for SMDS Over BISDN UNI SR will be mailed to designated client representatives by 9/30/91. This SR will define a preliminary protocol architecture for providing SMDS over a BISDN access line.

No: 005

Original: *Commitment Date:* 4Q91

Issue 1 BISDN User-Network Access Signaling TA (TA-TSY-001111) will be mailed to the industry from Bellcore by 12/31/91. This TA will define user-network signaling (which is expected to build on the Q.931 recommendation for narrowband ISDN) for BISDN.

No: 006

Original: *Commitment Date:* 4Q91

Issue 1 BISDN Interface Framework TA (FA-TSY-001113) will be mailed to the industry from Bellcore by 12/31/91. This doucment will provide preliminary interface requirements for the User-Network Interface (UNI), and the Network Node Interface (NNI), and Interworking units (IWU).

No: 007

Original: *Commitment Date:* 4Q91

Operations Technology Strategy for BISDN SR will be mailed to designated client representatives by 12/31/91. This SR will provide an analysis of NE operations functionality for BISDN, to be used as input to future Operations Technology, Switching, and Transport TAs.

Project Name: BISDN PHASE 1 PLNG & REQUIREMENTS
Project No.: 1R3011

DELIVERABLES: (CONT.)

No: 008
Original: *Commitment Date:* ONGO
Ongoing contributions to key standards bodies - will provide ongoing participation in and contributions to CCITT and T1 work on BISDN. Status reports on standards activities related to BISDN will be mailed to designated client representatives by 6/30/91 and 12/31/91.

No: 009
Original: *Commitment Date:* 4Q91
An update to the BISDN Phase 1 prospectus will be mailed to designated BCC representatives by 12/31/91. This update will incorporate additional economic, market, and stakeholder analysis relevant to initial BISDN deployment.

No: 010
Original: *Commitment Date:* 3Q91
Deliver a document on the results of preliminary laboratory testing efforts for Data Communications Service Concepts. This acitvity will support BISDN via hands-on analysis of service opportunities.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1ONS2X

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The output from this project will assist BCCs in moving initial BISDN from the research and planning stage to initial deployment in BCC networks. Future Bellcore work on BISDN, as well as other Bellcore products such as INA and INet will depend upon work completed in this project.

Project Name: BISDN PHASE 1 PLNG & REQUIREMENTS

Project No.: 1R3011

REASON FOR INFRASTRUCTURE CLASSIFICATION: (CONT.)

The substantial benefits of this project will accrue to all Owner-Clients and can not be prevented from accruing to an Owner-Client who might elect not to participate in this project.

BELLCORE

1991 FINAL PROJECT OFFERING

Project Name: BISDN PHASE 1 PLNG & REQUIREMENTS	Project No.: 1R3011
Bellcore Project Manager: NA	Tel. No.: (000) 000-0000
Bellcore Program Manager: N/A	Tel. No.: (N/A) -
Bellcore Subject Matter Expert: NA	Tel. No.: (000) 000-0000

Bellcore Product Name:
BISDN PHASE 1

This Project supports the following Major Product(s):
BISDN PHASE 1

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	MULTI-YEAR	Start Date: 01/91 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH. SVCS.	312-805-2500
BA	Y	R. ALBERS	AVP - TECH. PLNG.	703-974-8005
BS	Y	D. KETTLER	AVP - SCI. & TECH	404-529-2602
NX	Y	R. HELGESEN	MNG. DIR. NTWK. PLNG.	914-683-2034
PB	Y	R. IRELAND	AVP - TECH. PLNG.	415-823-7600
SW	Y	J. CARPENTER	AVP - TECH. PLNG. & DEV.	314-235-1550
US	Y	J. CZAK	DIR.- NTWK. ARCH. & STDS.	303-889-6409

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name: SCAI AND INTELLIGENT NETWORK STANDARDS
Project No.: 1R4127

Bellcore Product Manager: C. WILLCOCK
Tel. No.: (908) 758-2321

This Project is a Component of the Bellcore Product: AIN RELEASE 1

New Date: 08/08/90

PROJECT OVERVIEW:

Advanced Intelligent Network Release 1 (AIN R1) is defined as the set of network changes targeted for 1994 that evolve the Bellcore Client Companies' (BCCs') networks toward meeting AIN goals of programmability, multi-vendor environment, and standard interfaces. The R1 architecture will incorporate the attributes of the various AIN Release 0 architectures deployed in 1991 and 1992, increase their functionality, and bring the network a step closer to the Information Networking Architecture (INA) target.

The major benefit of this Project is that it provides for Bellcore participation in Switch Computer Applications Interface (SCAI) and Intelligent Network Standards activities in CCITT and T1S1. This participation will help support the formulation of requirements for a service-independent, vendor-independent platform which will facilitate the deployment of new revenue-generating services in your company's network. There is a need for consistency, as much as possible, between Bellcore's generic requirements for AIN R1 and emerging standards. Such consistency with national and international standards will allow a broader range of suppliers to be available and provide more assurance that products from different suppliers will interoperate satisfactorily.

This Project will help Bellcore and the BCCs maintain their technical leadership position in the Intelligent Network (IN) arena.

Key assumptions are that:

- Vendor products based on AIN R1 requirements need to be available in the 1994 time frame;
- The requirements will be based on the AIN R1 Baseline Architecture and the AIN R1 Network and Operations Plan.

DESCRIPTION OF 1991 WORK:

Bellcore will be active in national and international standards bodies relevant to IN and SCAI. In particular, activities will be focused on T1S1 and CCITT.

Project Name: SCAI AND INTELLIGENT NETWORK STANDARDS
Project No.: 1R4127

DESCRIPTION OF 1991 WORK: (CONT.)

Bellcore will:

- Provide contributions consistent with our views of AIN and INA and with the needs of the BCCs.
- Provide service analyses where they are needed to support standards efforts.
- Take organizational and technical leadership roles where possible.
- Support BCC commitments to standards and coordinate BCC positions.
- Review and comment on other organizations' contributions to standards bodies.

Areas in which contributions could be made for SCAI Standards include: SCAI requirements (applications, service descriptions), SCAI transport (Q.931, X.25, SS7), and SCAI protocol (layer 7).

Areas in which contributions could be made for IN Standards include: physical architecture options, functional interface specifications (including internetworking), service analysis, and protocol specifications.

DELIVERABLES:

No: 001
Original: *Commitment Date:* ONGO
Support for Switch Computer Applications Interface (SCAI) standards activities, including participation in T1S1.

No: 002
Original: *Commitment Date:* ONGO
Support for Intelligent Network (IN) standards activities, including participation in and contributions to T1S1 and CCITT.

Project Name: Project No.:
SCAI AND INTELLIGENT NETWORK STANDARDS 1R4127

DELIVERABLES: (CONT.)

No: 003
Original: *Commitment Date:* ONGO
Continuation of the analysis of the relationship of Switch Computer Applications Interface (SCAI) to AIN R1.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1R4111

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1991 FINAL PROJECT OFFERING

Project Name: SCAI AND INTELLIGENT NETWORK STANDARDS
Project No.: 1R4127

Bellcore Project Manager: N/A
Tel. No.: (000) 000-0000

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: N/A
Tel. No.: (000) 000-0000

Bellcore Product Name:
AIN RELEASE 1

This Project supports the following Major Product(s):
AIN RELEASE 1

Council:	Committee:	Forum:
NOT APPLICABLE	NOT APPLICABLE	NETWORK SERVICES

FUNDING REQUIREMENTS

Project Type:	Work Category:		
MULTI CLIENT	NEWLY ESTABLISH	SINGLE-YEAR	Start Date: 01/91 Completion Date: 12/91 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 07 | Firm Quote: YES

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH. SERVICES	312-605-2500
BA	Y	R. ALBERS	AVP - TECH. PLANNING	703-974-8006
BS	Y	D. KETTLER	DIR. - SCIENCE & TECH.	404-529-2602
NX	Y	R. HELGESEN	MNG. DIR. - NTWK. PLNG.	914-683-2034
PB	N	N/A	N/A	N/A
SW	N	N/A	N/A	N/A
US	Y	A. BOUTA	DIRECTOR	612-344-6118

Research Tax Credit Application:

B E L L C O R E

1991 FINAL PROJECT OFFERING

Project Name: INFORMATION NETWORKING ARCHITEC (INA)	Project No.: 1R501N
Bellcore Product Manager: N. PETSCHENIK	Tel. No.: (908) 758-2151
This Project is a Component of the Bellcore Product: INF. NTWK. ARCH	
Significant Change Date: 08/09/90	

PROJECT OVERVIEW:

Bellcore Client Companies (BCCs) need Information Networking Architecture (INA) to drive network and system products in consistent, covergent directions; to achieve rapid and effective development of information networking exchange and exchange access services; and to achieve the modularity that facilitates multi-vendor solutions.

To meet these client needs the Information Networking Architecture Project defines a target architecture capable of achieving desirable network/operations attributes and guiding the incorporation of INA concepts into network products and operations systems. The target architecture will build on national and international Standards, Industry Group directions, and existing Bellcore/BCC architecture efforts such as the OSCA (TM) Architecture.

OSCA is a trademark of Bellcore.

DESCRIPTION OF 1991 WORK:

This project meets BCC needs by defining INA: the principles and specifications for an integrated structure that drives the development of information technologies to facilitate rapid implementation of Information Networking exchange and exchange access services. Testbeds are used to validate architecture concepts.

In 1991, this project produces an overall INA Framework (deliverable 001). The INA Framework will contain information on two of the component architectures. The application development and interoperability architecture describes the constraints on the protocols and specifications that are necessary for development of modular, independent entities that are able to interoperate within a distributed processing environment. The concepts, guidelines, and principles provided by this component architecture pertain to how entities within the network interact among themselves and with entities outside of the network. The deployment architecture is the set of guidelines on how objects are mapped into applications and how those applications are deployed in nodes.

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Project Name:
INFORMATION NETWORKING ARCHITEC (INA)

Project No.:
1R501N

DESCRIPTION OF 1991 WORK: (CONT.)

The project works jointly with Project 1R502X to provide detailed definition of the INA Enterprise Architecture (deliverable 003), and the Object Architecture. The Enterprise Architecture describes what the business does, including identification and definition of the business' processes, information, and interrelationships required to operate the business. The Object Architecture groups information and functions into objects, and specifies the semantics of their interfaces.

During the multi-year period in which INA is defined, a key role of this project is to influence the planners and engineers (in Bellcore, in the BCCs, and in the vendor community) who are defining requirements for products that BCCs will implement during the 90s and beyond. Thus, INA will guide a progressive series of network and system changes converging on a common set of attributes and a target architecture in support of business needs. For this purpose, the INA Framework (deliverable 001) will be delivered to BCC and Bellcore Subject Matter Experts in 1991, and will be released to Industry in 1Q92. To insure that the appropriate linkages are achieved between INA and the INet Product Set (see projects 1R4211 - AIN Release 2, 1R3111 - BISDN Phase 2, 1R1311 - ISDN Phase 2) the INA Project will also produce technical expositions that supplement the INA Framework on topics critical to planners and engineers for the INet Product Set. The availability of these expositions will be synchronized with the INet schedule. The topics for the expositions will be selected and reviewed with BCCs to meet specific needs of Bellcore and BCC planners.

The INA Work Program Plan provides an overall road map of the architecture evolution that provides leadership for how we will move towards the target. The overall goal is to have an "INA consistent entity" in the field in 1998 (first office application). However, major interim milestones will be achieved. Products that have already been influenced by INA attributes will start to be available from vendors in the early 90s (e.g., AIN Release 1, SMSDS Phase 2). Products that are strongly influenced by INA will start to be available from vendors in the mid to late 90s (i.e., the INet Product Set).

INA Initiatives are efforts that accelerate the transition to INA. An initiative is intended to focus the target definition work to meet the needs of a specific, measurable business opportunity. The role of INA Initiatives are summarized in the INA Work Program Plan (deliverable 002). The results of the work on initiatives and plans for future initiatives are summarized in the INA Status Report (deliverable 006). Experience with the INA Data Redundancy Management Initiative during 1990 will determine the approach to future INA initiatives.

Project Name: INFORMATION NETWORKING ARCHITEC (INA)
Project No.: 1R501N

DESCRIPTION OF 1991 WORK: (CONT.)

The expected benefits that motivate the development of INA are:

- BCCs will be able to develop and deploy services that use network and operations capabilities more rapidly and at lower cost,

- data will be shared more effectively

- the modular, layered structure will encourage competition among an increased number of vendors which will improve vendor offerings,

- due to modulization and separation of modules through interfaces that support interoperability attributes, BCC assets will be able to be managed in smaller units, thus decreasing the impact of changes

- opportunities will be created for new types of services and revenue streams.

INA deliverables will be distributed to all relevant SME groups and governance bodies by the commitment date to help assure that architecture and planning activities within the BCCs are coordinated with the evolution of the INA definition.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 1291
INA Framework, Issue 1 provides the high-level concepts, principles and guidelines for INA with emphasis on application development, interoperability and deployment. This document will be delivered to appropriate governance bodies and SMEs (within the BCCs and Bellcore) for final approval so that the document can be available for ordering by industry by 3/31/92.

No: 002
Original: *Commitment Date:* 0691
The INA Work Program Plan, Issue 2 provides detail on the steps in the definition of the architecture, and how internal and external communication goals will be achieved.

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1991 FINAL PROJECT OFFERING

Project Name: INFORMATION NETWORKING ARCHITEC (INA)
Project No.: 1R501N

DELIVERABLES: (CONT.)

No: 003
Original: *Commitment Date:* 1291
The Enterprise Architecture, Issue 2 is a joint deliverable with project 1R502X. It provides the next level of detail from Issue 1 by bringing the decomposition down to the level of applications and allowing object definition to proceed.

No: 004
Original: *Commitment Date:* ONGO
INA expositions supplement the INA Framework with detailed topics critical to planners and engineers for the INet Product Set. The specific topics and schedule will be determined and reviewed by BCCs by the end of 1990.

No: 005
Original: *Commitment Date:* ONGO
Participation in relevant National and International direction setting work such as TINA, ANSA, TRON and other projects to be determined as a follow-up to 1990 of Standards/Industry Assessment.

No: 006
Original: *Commitment Date:* 1291
The INA Status Report will review the progress that INA made in 1991, including participation in national and international industry groups and standards bodies, the status of the Architecture Review Board in Bellcore, and progress on INA initiatives.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

625SSA

Project Name: INFORMATION NETWORKING ARCHITEC (INA)
Project No.: 1R501N

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work in this project provides a common base for many other Bellcore projects for evolving standards, architecture and specifications for communications, operations, and information access.

The substantial benefits of this project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this project.

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1991 FINAL PROJECT OFFERING

Project Name:
INFORMATION NETWORKING ARCHITEC (INA)

Project No.:
1R501N

Bellcore Project Manager:
NA

Tel. No.:
(000) 000-0000

Bellcore Program Manager:
N/A

Tel. No.:
(N/A) -

Bellcore Subject Matter Expert:
NA

Tel. No.:
(000) 000-0000

Bellcore Product Name:
INF. NTWK. ARCH

This Project supports the following Major Product(s):
INF. NTWK. ARCH

Council:
RESEARCH & NETWORK

Committee:
NETWORK STAND. & ARCH.

Forum:
NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		Start Date: 01/84
			Completion Date: 12/92
INFRASTRUCTURE	PREVIOUSLY FUND	MULTI-YEAR	Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01

Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH SVCS	312-606-2500
BA	Y	R. ALBERS	AVP - TECH PLNG	703-974-8005
BS	Y	D. KETTLER	DIR - SCI & TECH	404-529-2602
NX	Y	R. HELGESEN	MNG DIR - NTWK PLNG	914-683-2034
PB	Y	R. IRELAND	AVP - TECH PLNG	415-823-7600
SW	Y	J. CARPENTER	AVP - TECH PLNG & DEV	314-235-1550
US	Y	J. CZAK	DIR - NTWK ARCH & STDS	303-889-6409

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name: INTEGRATED OPERATIONS SUPPORT OF INA
Project No.: 1R502X

Bellcore Product Manager: N. PETSCHENIK
Tel. No.: (908) 758-2151

This Project is a Component of the Bellcore Product: INF. NTWK. ARCH

Significant Change Date: 08/31/90

PROJECT OVERVIEW:

This project provides leadership in the planning, analysis, and definition of the Information Networking Architecture (INA) Enterprise Architecture and the INA Object Architecture, and continues the development of the Strategic Data Architecture (SDA) and the Corporate Logical Data Model (CLDM).

Development of requirements for INA-consistent products is dependent on the understanding and documentation of an agreed upon, clearly defined Enterprise Architecture. The Enterprise Architecture is the set of functions, information, and their interrelationships that define what a Bellcore Client Company (BCC) telecommunications business does to provide its products and services to its customers. It includes a decomposition of individual business functions and an integrated model of functions, information, and their interactions for the BCCs. The Enterprise Architecture provides a high level view of the information needs. Its scope is enterprise-wide, covering all aspects that deliver and support services and products. The Enterprise Architecture is a prerequisite for defining the INA Object Architecture, which will group information and functions into objects, and specify the semantics of their interfaces.

This project will also coordinate logical data modeling work in Bellcore, yielding a CLDM. The techniques, approaches and structures developed for the CLDM are expected to be used in developing the Object Architecture. The CLDM is a consolidated view, across the corporation, of data, the operations that are allowed against that data, and the results of applying those operations. The CLDM is developed by integrating the various Logical Data Models (LDMs) that describe views of corporate information. A LDM is a structured and systematic representation of the information and functions allowed on that information, required for a product. This representation is independent of the technologies underlying the product. This modeling will result in TAs and TRs that may be issued to the industry either separately, or included as part of a requirements document for a specific product or interface.

The project will also manage changes to the subject data areas and objects of the SDA suggested by the information needs identified by the Enterprise Architecture, by information modeling,

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Project Name:
INTEGRATED OPERATIONS SUPPORT OF INA

Project No.:
1R502X

PROJECT OVERVIEW: (CONT.)

and by the BCCs. The project will also provide consultation and review services for ongoing information modeling work within Bellcore. This project will include the coordination and support of joint BCC planning groups with an interest in the Enterprise Architecture, the SDA (which will be incorporated into the Enterprise Architecture), and the CLDM, primarily the Data Architecture Resource Team (DART).

DESCRIPTION OF 1991 WORK:

This work will:

- Lead continuing work on the Enterprise Architecture. This work includes the further decomposition of the functions and information of the Enterprise Architecture, Issue 1, that will be used as input to the Corporate Logical Data Model and the INA Object Architecture. The Enterprise Architecture, Issue 2 (deliverable 001) will provide enough details of BCCs' business that specific applications and technical requirements can be developed. This will require consultation with those who develop requirements to ensure that their needs are met.

- Specify how the functions and information developed in the Enterprise Architecture are mapped into logical groups of functions and groups of information, based on a number of criteria, such as performance and information needs.

- Support the continuing development of the Strategic Data Architecture, which will be incorporated into the Enterprise Architecture. The work will determine the impact on the SDA of new data elements discovered in the Enterprise Architecture work, during logical data modeling, and as suggested by BCCs via DART; this work analyzes the impact of these data elements on the SDA and updates the SDA accordingly. It promotes the alignment of Bellcore's SDA with strategic architectures of the BCCs.

- Coordinate logical data modeling activities and the ongoing integration of Logical Data Models with the emerging Corporate Logical Data Model. Primary data modeling activities requiring coordination are those associated with LDMs developed for Network and Operations product requirements, such as Advanced Intelligent Network (AIN) or Data Collection Operations System (DCOS) and the Managed Information Base (an OSI standard). Although the development of LDMs is widely distributed among organizations developing requirements and supporting data base work, this work centralizes the coordination, administration, standards, and tools used for information modeling.

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Project Name: INTEGRATED OPERATIONS SUPPORT OF INA

Project No.: 1R502X

DESCRIPTION OF 1991 WORK: (CONT.)

The Enterprise Architecture and the Object Architecture describe long-term targets for the BCCs from a global perspective. The SDA and CLDM build towards these long-term targets. The benefit of this work is that it provides an overall context for planning future systems, resulting in systems that avoid unnecessary redundancy in function, manage data efficiently, are less expensive to build, and require fewer resources to maintain.

INA deliverables will be distributed to all relevant SME groups and governance bodies by the commitment date to help assure that architecture and planning activities within the BCCs are coordinated with the evolution of the INA definition.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 1291
Enterprise Architecture, Issue 2, is a joint deliverable with project 1R501N. It provides the next level of detail from Issue 1 by bringing the decomposition down to the level of applications and allowing object definition to proceed.

No: 002
Original: *Commitment Date:* 1291
This Strategic Data Architecture Issue 4 is an update to the Bellcore Strategic Data Architecture. It reflects information needs identified by the Enterprise Architecture, information modeling efforts, and the BCCS.

No: 003
Original: *Commitment Date:* ONGO
Corporate Logical Data Model Coordination - Inspect Product Data Architectures (e.g., AIN, DCOS) and provide Data Architecture Review readouts to designated client representatives as they are needed. Integrate product Logical Data Models with the emerging CLDM. Provide consulting on Data Modeling and LDM issues to Bellcore SMEs.

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Project Name: INTEGRATED OPERATIONS SUPPORT OF INA
Project No.: 1R502X

REASON FOR INFRASTRUCTURE CLASSIFICATION:

The work in this project provides a common base for many other Bellcore projects for evolving standards, architecture and specifications for communications, operations, and information access.

The substantial benefits of this project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in the project.

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1991 FINAL PROJECT OFFERING

Project Name: INTEGRATED OPERATIONS SUPPORT OF INA
Project No.: 1R502X

Bellcore Project Manager: J. F. URICH
Tel. No.: (201) 829-2184

Bellcore Program Manager: J. F. URICH
Tel. No.: (201) 829-2184

Bellcore Subject Matter Expert: D. B. LUBER
Tel. No.: (201) 829-2166

Bellcore Product Name: INF. NTWK. ARCH

This Project supports the following Major Product(s):
INF. NTWK. ARCH

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NETWORK SERVICES

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	MULTI-YEAR	Start Date: 01/91 Completion Date: 12/91 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:

SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	B. FIKE	SR. DIR. - NETWORK ARCH.	708-605-2880
BA	Y	R. ALBERS	AVP - TECHNOLOGY PLANNING	703-974-8006
BS	Y	D. KETTLER	DIRECTOR - SCIENCE & TECH	404-529-2602
NX	Y	R. HELGESEN	MNG. DIR. - NETWORK PLNG.	914-683-2024
PB	Y	R. IRELAND	AVP - TECHNOLOGY PLANNING	415-823-7600
SW	Y	J. CARPENTER	AVP - TECHNOLOGY PLANNING	314-235-1550
US	Y	D. MALMSTROM	TECHNICAL DIRECTOR	303-740-1596

Research Tax Credit Application:

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Project Name:
INFORMATION NETWORKING ISDN PLANNING

Project No.:
1R1311

Bellcore Product Manager:
J. RIZZO

Tel. No.:
(908) 758-2211

This Project is a Component of the Bellcore Product:
ISDN PHASE 2.0

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

The BCCs are evolving from being premier providers of exchange and exchange access telephony to being premier providers of access to information in any form. This evolution is being driven by the growing demands of the telecommunications marketplace and the need for the BCCs to meet these demands by offering a widening set of services to their customers.

As initial steps in the evolution toward information networking, Bellcore is working on a set of new network platforms and technologies (ISDN Phases 1.1 and 1.2, AIN Release 1, BISDN Phase 1, SONET Releases 1 and 2, etc.) that are targeted for deployment by the Bellcore Client Companies (BCCs) throughout the first half of the 1990s. In addition, Bellcore is working with the BCCs to define a target architecture for the network (operations systems are included in the term "network" in this project profile) in the Information Networking Architecture (INA) product. Bellcore and the BCCs expect that the network of the mid-1990s will be an evolution and integration of the early/mid-1990s platforms and technologies, and a transition step toward the INA target, that will result in the BCCs ability to offer a range of information networking services in a cost-effective manner.

The work in 1991 to define the network of the mid-1990s will take place in a set of products called the Information Networking (INET) product set that consists of the AIN Release 2, BISDN Phase 2 and ISDN Phase 2 products. This product structure was established principally for administrative purposes and the product set will, in fact, be managed as a single Bellcore product having a single set of outputs in 1991. The project described here (1R1311) is one of the projects that is contained in this product set, the others being the Information Networking BISDN Planning (1R3111) and Information Networking AIN Planning (1R4211) projects. In addition to these projects, a portion of Project 10NS2X, Operations Planning for Network Products, will be applied to the efforts in this and the other projects in this set to perform the operations planning functions.

The principal goal of this product set (and thus the work in this project) is to enable the BCCs to deploy products beginning in the mid-1990s that allow them to provide, via a service-creation environment, cost-effective media-independent (including mixed-media)

Project Name: INFORMATION NETWORKING ISDN PLANNING
Project No.: 1R1311

PROJECT OVERVIEW: (CONT.)

switching and transport services at a range of information rates. These services must complement the functionality in CPE and other networks to facilitate end-to-end customer applications. The work in this project and the others in this set will take a network-wide view of the various functionality (transmission, switching, control, operations, access, signaling, etc.) that will be required to achieve this goal and will ultimately result in the production of requirements for products having the needed functionality that can be deployed in the mid-1990s.

The planning and system engineering work in this project, along with the other projects noted above, will incorporate the upfront work necessary to demonstrate the business, technical, and market viability of information networking in the mid-1990s. This will include preliminary architecture planning, market, stakeholder, and economic analysis, technical feasibility analysis, and transition planning. This information will enable the BCCs to determine whether to pursue the development of an Integrated Network and Operations Plan (N&OP), followed by generic requirements for information networking products and ultimately their deployment in the mid-1990s. Deployment of products based on the Integrated Network and Operations Plan would provide the BCCs with new revenue opportunities by enabling them to provide a diverse set of information networking services targeted to their specific markets and would provide them with cost reduction opportunities through the integration of similar functions in a logical networking environment.

DESCRIPTION OF 1991 WORK:

In 1991, the INET product set will be in the Concept Development Stage of the Network Service and Technology Process (NSTP). The purpose of the Concept Development Stage is to define more comprehensively the opportunity being addressed by the product and to begin to identify a solution that is technically sound and economically viable.

To meet these objectives in 1991, Bellcore will develop and provide the BCCs with technical and business information enabling them to decide whether to pursue mid-1990s deployment of information networking. This information will be contained in an Opporutunity Analysis for the mid-1990s network, followed by a prospectus, as described below. This work will be based on architecture, technology and services work done in 1990 in several projects that have been mapped to INET.

The Opportunity Analysis (OA) is essentially a first cut at the prospectus and would consist of the following information:

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Project Name: INFORMATION NETWORKING ISDN PLANNING   Project No.: 1R1311

DESCRIPTION OF 1991 WORK: (CONT.)

- o An initial cut at a functional description of the network of the mid-1990s.

- o Identification of a set of services, some of which would be of the integrated voice/data variety, that customers may need in the mid-1990s, as well as ballpark estimates of demand and revenue. These services would likely be based on past and current (i.e., 1990) market research and service concept efforts at Bellcore, as well as on input from the BCCs.

- o A high-level architectural view of the network (including the operations) and rough estimates of the cost of the elements. Analyses of how the above-mentioned services would be provided on the architecture would be included, as well as some of the technical issues associated with transition and evolution from earlier platforms.

- o Utilizing all of the above information, a preliminary economic analysis of the mid-90s network would be conducted and used by BCCs to decide whether work should continue toward the next stage of the NSTP.

Following the Opportunity Analysis, and assuming a go-ahead decision by the BCCs (most likely, by the Network & Operations Architecture (N&OA) Product Support Group (PSG)), work on a prospectus will begin. This prospectus will incorporate Bellcore market, stakeholder, technical, and economic analysis to provide the BCCs with information enabling them to decide whether further support for mid-1990s deployment of Information Networking is justified. This prospectus will include:

- o Market analysis for a set of information networking core services, including revenue potential and customer willingness to pay;

- o Identification of relevant stakeholders and recommendations for influencing those stakeholders;

- o A recommended standards strategy;

- o Economic analysis of information networking and information networking core services including projection of total lifecycle costs, revenues and cost reduction opportunities.

Also included in the prospectus will be a preliminary Integrated Network and Operations Plan that will consist of the following:

- o A description of the functionality proposed for the network of the mid-1990s.

- o Preliminary partitioning of this functionality and information

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Project Name: INFORMATION NETWORKING ISDN PLANNING
Project No.: 1R1311

DESCRIPTION OF 1991 WORK: (CONT.)

into network and operations elements, as well as elements external to the network (such as CPE).

- o Initial description of the interfaces between elements in the network and between the network and external entities, and identification of strategies for managing redundant data.
- o Overview description of the way internal and external users will interact with the information networking platform and information networking services;
- o Overview description of the service creation capabilities required to meet user needs;
- o General strategy to enable the transition from embedded systems and previously-defined platforms.

This prospectus is a major milestone and decision point for the BCCs in that it proposes what the network of the mid-1990s will look like and what functionality it will provide (and why). Assuming BCC concurrence with the recommendations provided in the prospectus, Bellcore will begin the detailed work on the Integrated Network and Operations Plan which is targeted for completion in 1992.

In summary, this project, in conjunction with the other projects in the INET product set, provides benefits to the BCCs by providing them with the basic systems engineering and planning to enable them to pursue a consistent evolution towards a single integrated network encompassing both "network" and "operations" capabilities. This single integrated network will provide the BCCs with new revenue opportunities for transport services, value-added services, and unbundled capabilities, and will present the BCCs with opportunities for cost reduction through the integration of similar functions in a single logical networking structure.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 0391
Opportunity Analysis - Provides an analysis of the service and cost reduction opportunities that may warrant evolving the network, a high-level architectural view of the network and preliminary economic and stakeholder analyses. This deliverable will be mailed to the N&OA PSG in March 1991 and should be used by N&OA to determine whether any changes in assumptions, directions, etc., are required in developing the Prospectus.

Project Name: INFORMATION NETWORKING ISDN PLANNING
Project No.: 1R1311

DELIVERABLES: (CONT.)

No: 002
Original:
Commitment Date: 1091
Prospectus - Provides comprehensive business analysis for the information networking platform of the mid-1990's and a preliminary Integrated Network and Operations Plan providing technology, architecture and transition information. This deliverable will be mailed to the N&OA PSG in October 1991 and should be used by N&OA in formulating a decision to begin detailed work on the N&OP.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1R4211 1R3111 10NS2X

Provides To:

1R3111 1R4211

REASON FOR INFRASTRUCTURE CLASSIFICATION:

This project provides the conceptualization, planning, analysis, and related testing of fundamental compatible network and operations architectures, capabilities, and systems, and analysis for Bellcore's use of the potential impacts on standards and architecture, and the services supported by the network, of industry issues.

The substantial benefits of this project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this project.

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1991 FINAL PROJECT OFFERING

Project Name:
INFORMATION NETWORKING ISDN PLANNING

Project No.: 1R1311

Bellcore Project Manager:
NA
Tel. No.: (000) 000-0000

Bellcore Program Manager:
N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert:
NA
Tel. No.: (000) 000-0000

Bellcore Product Name:
ISDN PHASE 2.0

This Project supports the following Major Product(s):
ISDN PHASE 2.0 AIN RELEASE 2 BISDN PHASE 2

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	MULTI-YEAR	Start Date: 01/91 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:
SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH. SVCS.	312-605-2500
BA	Y	R. ALBERS	AVP - TECH. PLNG.	703-974-8005
BS	Y	D. KETTLER	AVP - SCI. & TECH.	404-529-2602
NX	Y	R. HELGESEN	MNG. DIR. NTWK. PLNG.	914-683-2034
PB	Y	R. IRELAND	AVP - TECH. PLNG.	415-823-7600
SW	Y	J. CARPENTER	AVP - TECH. PLNG. DEV.	314-235-1550
US	Y	J. CZAK	DIR.- NTWK. ARCH. & STDS.	303-889-6409

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name:	Project No.:
INFORMATION NETWORKING BISDN PLANNING	1R3111
Bellcore Product Manager:	Tel. No.:
J. RIZZO	(908) 758-2211

This Project is a Component of the Bellcore Product:
BISDN PHASE 2

Significant Change Date:
08/31/90

PROJECT OVERVIEW:

The BCCs are evolving from being premier providers of exchange and exchange access telephony to being premier providers of access to information in any form. This evolution is being driven by the growing demands of the telecommunications marketplace and the need need for the BCCs to meet these demands by offering a widening set of services to their customers.

As initial steps in the evolution toward information networking, Bellcore is working on a set of new network platforms and technologies (ISDN Phases 1.1 and 1.2, AIN Release 1, BISDN Phase 1, SONET Releases 1 and 2, etc.) that are targeted for deployment by the Bellcore Client Companies (BCCs) throughout the first half of the 1990s. In addition, Bellcore is working with the BCCs to define a target architecture for the network (operations systems are included in the term "network" in this project profile) in the Information Networking Architecture (INA) product. Bellcore and the BCCs expect that the network of the mid-1990s will be an evolution and integration of the early/mid-1990s platforms and technologies, and a transition step toward the INA target, that will result in the BCCs ability to offer a range of information networking services in a cost-effective manner.

The work in 1991 to define the network of the mid-1990s will take place in a set of products called the Information Networking (INET) product set that consists of the AIN Release 2, BISDN Phase 2 and ISDN Phase 2 products. This product structure was established principally for administrative purposes and the product set will, in fact, be managed as a single Bellcore product having a single set of outputs in 1991. The project described here (1R3111) is one of the projects that is contained in this product set, the others being the Information Networking ISDN Planning (1R1311) and Information Networking AIN Planning (1R4211) projects. In addition to these projects, a portion of Project 10NS2X, Operations Planning for Network Products, will be applied to the efforts in this and the other projects in this set to perform the operations planning functions.

The principal goal of this product set (and thus the work in this project) is to enable the BCCs to deploy products beginning in the mid-1990s that allow them to provide, via a service-creation environment, cost-effective media-independent (including mixed-media)

Project Name: INFORMATION NETWORKING BISDN PLANNING
Project No.: 1R3111

PROJECT OVERVIEW: (CONT.)

switching and transport services at a range of information rates. These services must complement the functionality in CPE and other networks to facilitate end-to-end customer applications. The work in this project and the others in this set will take a network-wide view of the various functionality (transmission, switching, control, operations, access, signaling, etc.) that will be required to achieve this goal and will ultimately result in the production of requirements for products having the needed functionality that can be deployed in the mid-1990s.

The planning and system engineering work in this project, along with the other projects noted above, will incorporate the upfront work necessary to demonstrate the business, technical, and market viability of information networking in the mid-1990s. This will include preliminary architecture planning, market, stakeholder, and economic analysis, technical feasibility analysis, and transition planning. This information will enable the BCCs to determine whether to to pursue the development of an Integrated Network and Operations Plan (N&OP), followed by generic requirements for information networking products and ultimately their deployment in the mid-1990s. Deployment of products based on the Integrated Network and Operations Plan would provide the BCCs with new revenue opportunities by enabling them to provide a diverse set of information networking services targeted to their specific markets and would provide them with cost reduction opportunities through the integration of similar functions in a logical networking environment.

DESCRIPTION OF 1991 WORK:

In 1991, the INET product set will be in the Concept Development Stage of the Network Service and Technology Process (NSTP). The purpose of the Concept Development Stage is to define more comprehensively the opportunity being addressed by the Product and to begin to identify a solution that is technically sound and economically viable.

To meet these objectives in 1991, Bellcore will develop and provide the BCCs with technical and business information enabling them to decide whether to pursue mid-1990s deployment of information networking. This information will be contained in an Opporutunity Analysis for the mid-1990s network, followed by a Prospectus, as described below. This work will be based on architecture, technology and services work done in 1990 in several projects that have been mapped to INET.

The Opportunity Analysis (OA) is essentially a first cut at the Prospectus and would consist of the following information:

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Project Name: INFORMATION NETWORKING BISDN PLANNING
Project No.: 1R3111

DESCRIPTION OF 1991 WORK: (CONT.)

- o An initial cut at a functional description of the network of the mid-1990s.

- o Identification of a set of services, some of which would be of the integrated voice/data variety, that customers may need in the mid-1990s, as well as ballpark estimates of demand and revenue. These services would likely be based on past and current (i.e.,

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Project Name: INFORMATION NETWORKING BISDN PLANNING
Project No.: 1R3111

PROJECT OVERVIEW: (CONT.)

switching and transport services at a range of information rates. These services must complement the functionality in CPE and other networks to facilitate end-to-end customer applications. The work in this project and the others in this set will take a network-wide view of the various functionality (transmission, switching, control, operations, access, signaling, etc.) that will be required to achieve this goal and will ultimately result in the production of requirements for products having the needed functionality that can be deployed in the mid-1990s.

The planning and system engineering work in this project, along with the other projects noted above, will incorporate the upfront work necessary to demonstrate the business, technical, and market viability of information networking in the mid-1990s. This will include preliminary architecture planning, market, stakeholder, and economic analysis, technical feasibility analysis, and transition planning. This information will enable the BCCs to determine whether to to pursue the development of an Integrated Network and Operations Plan (N&OP), followed by generic requirements for information networking products and ultimately their deployment in the mid-1990s. Deployment of products based on the Integrated Network and Operations Plan would provide the BCCs with new revenue opportunities by enabling them to provide a diverse set of information networking services targeted to their specific markets and would provide them with cost reduction opportunities through the integration of similar functions in a logical networking environment.

DESCRIPTION OF 1991 WORK:

In 1991, the INET product set will be in the Concept Development Stage of the Network Service and Technology Process (NSTP). The purpose of the Concept Development Stage is to define more comprehensively the opportunity being addressed by the Product and to begin to identify a solution that is technically sound and economically viable.

To meet these objectives in 1991, Bellcore will develop and provide the BCCs with technical and business information enabling them to decide whether to pursue mid-1990s deployment of information networking. This information will be contained in an Opporutunity Analysis for the mid-1990s network, followed by a Prospectus, as

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Project Name: INFORMATION NETWORKING BISDN PLANNING

Project No.: 1R3111

DESCRIPTION OF 1991 WORK: (CONT.)

into network and operations elements, as well as elements external to the network (such as CPE).

- Initial description of the interfaces between elements in the network and between the network and external entities, and identification of strategies for managing redundant data.

- Overview description of the way internal and external users will interact with the information networking platform and information networking services;

- Overview description of the service creation capabilities required to meet user needs;

- General strategy to enable the transition from embedded systems and previously-defined platforms.

This Prospectus is a major milestone and decision point for the BCCs in that it proposes what the network of the mid-1990s will look like and what functionality it will provide (and why). Assuming BCC concurrence with the recommendations provided in the Prospectus, Bellcore will begin the detailed work on the Integrated Network and Operations Plan which is targeted for completion in 1992.

In summary, this project, in conjunction with the other projects in the INET product set, provides benefits to the BCCs by providing them with the basic systems engineering and planning to enable them to pursue a consistent evolution towards a single integrated network encompassing both "network" and "operations" capabilities. This single integrated network will provide the BCCs with new revenue opportunities for transport services, value-added services, and unbundled capabilities, and will present the BCCs with opportunities for cost reduction through the integration of similar functions in a single logical networking structure.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 0391
Opportunity Analysis - Provides an analysis of the service and cost reduction opportunities that may warrant evolving the network, a high-level architectural view of the network and preliminary economic and stakeholder analyses. This deliverable will be mailed to the N&OA PSG in March 1991 and should be used by N&OA to determine whether any changes in assumptions, directions, etc., are required in developing the Prospectus.

Project Name: **INFORMATION NETWORKING BISDN PLANNING**

Project No.: **1R3111**

DELIVERABLES: (CONT.)

No: 002

Original: *Commitment Date:* 1091

Prospectus - Provides comprehensive business analysis for the information networking platform of the mid-1990's and a preliminary Integrated Network and Operations Plan providing technology, architecture and transition information. This deliverable will be mailed to the N&OA PSG in October 1991 and should be used by N&OA in formulating a decision to begin detailed work on the N&OP.

PROJECT FUNDING DEPENDENCIES:

1991

Receives From:

1R4211 1R1311 1ONS2X

Provides To:

1R1311 1R4211

REASON FOR INFRASTRUCTURE CLASSIFICATION:

This Project provides the conceptualization, planning, analysis, and related testing of fundamental compatible network and operations architectures, capabilities, and systems, and analysis for Bellcore's use of the potential impacts on standards and architecture, and the services supported by the network, of industry issues.

The substantial benefits of this Project accrue to all Owner-Clients and are unable to be prevented from accruing to an Owner-Client who might elect not to participate in this Project.

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Project Name: INFORMATION NETWORKING BISDN PLANNING
Project No.: 1R3111

Bellcore Project Manager: NA
Tel. No.: (000) 000-0000

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: NA
Tel. No.: (000) 000-0000

Bellcore Product Name: BISDN PHASE 2

This Project supports the following Major Product(s):
BISDN PHASE 2 ISDN PHASE 2.0 AIN RELEASE 2

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	MULTI-YEAR	Start Date: 01/91 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 | Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:
SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH. SVCS.	312-605-2500
BA	Y	R. ALBERS	AVP - TECH. PLNG.	703-974-8005
BS	Y	D. KETTLER	AVP - SCI. & TECH.	404-529-2602
NX	Y	R. HELGESEN	MNG. DIR. NTWK. PLNG.	914-683-2034
PB	Y	R. IRELAND	AVP - TECH. PLNG.	415-823-7600
SW	Y	J. CARPENTER	AVP - TECH PLNG. & DEV.	314-235-1550
US	Y	J. CZAK	DIR.- NTWK. ARCH. & STDS.	303-889-6409

Research Tax Credit Application:

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1991 FINAL PROJECT OFFERING

Project Name: INFORMATION NETWORKING AIN PLANNING	Project No.: 1R4211
Bellcore Product Manager: J. RIZZO	Tel. No.: (908) 758-2211
This Project is a Component of the Bellcore Product: AIN RELEASE 2	
Significant Change Date: 08/31/90	

PROJECT OVERVIEW:

The BCCs are evolving from being premier providers of exchange and exchange access telephony to being premier providers of access to information in any form. This evolution is being driven by the growing demands of the telecommunications marketplace and the need for the BCCs to meet these demands by offering a widening set of services to their customers.

As initial steps in the evolution toward information networking, Bellcore is working on a set of new network platforms and technologies (ISDN Phases 1.1 and 1.2, AIN Release 1, BISDN Phase 1, SONET Releases 1 and 2, etc.) that are targeted for deployment by the Bellcore Client Companies (BCCs) throughout the first half of the 1990s. In addition, Bellcore is working with the BCCs to define a target architecture for the network (operations systems are included in the term "network" in this project profile) in the Information Networking Architecture (INA) product. Bellcore and the BCCs expect that the network of the mid-1990s will be an evolution and integration of the early/mid-1990s platforms and technologies, and a transition step toward the INA target, that will result in the BCCs ability to offer a range of information networking services in a cost-effective manner.

The work in 1991 to define the network of the mid-1990s will take place in a set of products called the Information Networking (INET) product set that consists of the AIN Release 2, BISDN Phase 2 and ISDN Phase 2 products. This product structure was established principally for administrative purposes and the product set will, in fact, be managed as a single Bellcore product having a single set of outputs in 1991. The project described here (1R4211) is one of the projects that is contained in this product set, the others being the Information Networking ISDN Planning (1R1311) and Information Networking BISDN Planning (1R3111) projects. In addition to these projects, a portion of Project 10NS2X, Operations Planning for Network Products, will be applied to the efforts in this and the other projects in this set to perform the operations planning functions.

The principal goal of this product set (and thus the work in this project) is to enable the BCCs to deploy products beginning in the mid-1990s that allow them to provide, via a service-creation environment, cost-effective media-independent (including mixed-media)

Project Name: INFORMATION NETWORKING AIN PLANNING
Project No.: 1R4211

PROJECT OVERVIEW: (CONT.)

switching and transport services at a range of information rates. These services must complement the functionality in CPE and other networks to facilitate end-to-end customer applications. The work in this project and the others in this set will take a network-wide view of the various functionality (transmission, switching, control, operations, access, signaling, etc.) that will be required to achieve this goal and will ultimately result in the production of requirements for products having the needed functionality that can be deployed in the mid-1990s.

The planning and system engineering work in this project, along with the other projects noted above, will incorporate the upfront work necessary to demonstrate the business, technical, and market viability of information networking in the mid-1990s. This will include preliminary architecture planning, market, stakeholder, and economic analysis, technical feasibility analysis, and transition planning. This information will enable the BCCs to determine whether to pursue the development of an Integrated Network and Operations Plan (N&OP), followed by generic requirements for information networking products and ultimately their deployment in the mid-1990s. Deployment of products based on the Integrated Network and Operations Plan would provide the BCCs with new revenue opportunities by enabling them to provide a diverse set of information networking services targeted to their specific markets and would provide them with cost reduction opportunities through the integration of similar functions in a logical networking environment.

DESCRIPTION OF 1991 WORK:

In 1991, the INET product set will be in the Concept Development Stage of the Network Service and Technology Process (NSTP). The purpose of the Concept Development Stage is to define more comprehensively the opportunity being addressed by the product and to begin to identify a solution that is technically sound and economically viable.

To meet these objectives in 1991, Bellcore will develop and provide the BCCs with technical and business information enabling them to decide whether to pursue mid-1990s deployment of information networking. This information will be contained in an Opporutunity Analysis for the mid-1990s network, followed by a prospectus, as described below. This work will be based on architecture, technology and services work done in 1990 in several projects that have been mapped to INET.

The Opportunity Analysis (OA) is essentially a first cut at the Prospectus and would consist of the following information:

Project Name:	Project No.:
INFORMATION NETWORKING AIN PLANNING	1R4211

DESCRIPTION OF 1991 WORK: (CONT.)

- o An initial cut at a functional description of the network of the mid-1990s.

- o Identification of a set of services, some of which would be of the integrated voice/data variety, that customers may need in the mid-1990s, as well as ballpark estimates of demand and revenue. These services would likely be based on past and current (i.e., 1990) market research and service concept efforts at Bellcore, as well as on input from the BCCs.

- o A high-level architectural view of the network (including the operations) and rough estimates of the cost of the elements. Analyses of how the above-mentioned services would be provided on the architecture would be included, as well as some of the technical issues associated with transition and evolution from earlier platforms.

- o Utilizing all of the above information, a preliminary economic analysis of the mid-90s network would be conducted and used by BCCs to decide whether work should continue toward the next stage of the NSTP.

Following the Opportunity Analysis, and assuming a go-ahead decision by the BCCs (most likely, by the Network & Operations Architecture (N&OA) Product Support Group (PSG)), work on a prospectus will begin. This prospectus will incorporate Bellcore market, stakeholder, technical, and economic analysis to provide the BCCs with information enabling them to decide whether further support for mid-1990s deployment of Information Networking is justified. This prospectus will include:

- o Market analysis for a set of information networking core services, including revenue potential and customer willingness to pay;

- o Identification of relevant stakeholders and recommendations for influencing those stakeholders;

- o A recommended standards strategy;

- o Economic analysis of information networking and information networking core services including projection of total lifecycle costs, revenues and cost reduction opportunities.

Also included in the prospectus will be a preliminary Integrated Network and Operations Plan that will consist of the following:

- o A description of the functionality proposed for the network of the mid-1990s;

- o Preliminary partitioning of this functionality and information

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Project Name: Project No.:
INFORMATION NETWORKING AIN PLANNING 1R4211

DESCRIPTION OF 1991 WORK: (CONT.)

into network and operations elements, as well as elements external to the network (such as CPE);

- o Initial description of the interfaces between elements in the network and between the network and external entities, and identification of strategies for managing redundant data;
- o Overview description of the way internal and external users will interact with the information networking platform and information networking services;
- o Overview description of the service creation capabilities required to meet user needs;
- o General strategy to enable the transition from embedded systems and previously-defined platforms.

This prospectus is a major milestone and decision point for the BCCs in that it proposes what the network of the mid-1990s will look like and what functionality it will provide (and why). Assuming BCC concurrence with the recommendations provided in the prospectus, Bellcore will begin the detailed work on the Integrated Network and Operations Plan which is targeted for completion in 1992.

In summary, this project, in conjunction with the other projects in the INET product set, provides benefits to the BCCs by providing them with the basic systems engineering and planning to enable them to pursue a consistent evolution towards a single integrated network encompassing both "network" and "operations" capabilities. This single integrated network will provide the BCCs with new revenue opportunities for transport services, value-added services, and unbundled capabilities, and will present the BCCs with opportunities for cost reduction through the integration of similar functions in a single logical networking structure.

DELIVERABLES:

No: 001
Original: *Commitment Date:* 0391
Opportunity Analysis - Provides an analysis of the service and cost reduction opportunities that may warrant evolving the network, a high-level architectural view of the network and preliminary economic and stakeholder analyses. This deliverable will be mailed to the N&OA PSG in March 1991 and should be used by N&OA to determine whether any changes in assumptions, directions, etc., are required in developing the Prospectus.

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1991 FINAL PROJECT OFFERING

Project Name: INFORMATION NETWORKING AIN PLANNING
Project No.: 1R4211

Bellcore Project Manager: NA
Tel. No.: (000) 000-0000

Bellcore Program Manager: N/A
Tel. No.: (N/A) -

Bellcore Subject Matter Expert: NA
Tel. No.: (000) 000-0000

Bellcore Product Name: AIN RELEASE 2

This Project supports the following Major Product(s):
AIN RELEASE 2 ISDN PHASE 2.0 BISDN PHASE 2

Council:	Committee:	Forum:
RESEARCH & NETWORK	NETWORK STAND. & ARCH.	NOT APPLICABLE

FUNDING REQUIREMENTS

Project Type:	Work Category:		
INFRASTRUCTURE	NEWLY ESTABLISH	MULTI-YEAR	Start Date: 01/91 Completion Date: 12/92 Revised Comp Date: /

FUNDING ALLOCATION

Allocation Basis: 01 Firm Quote: NO

Non Affiliate Participation in this Project allowed: YES

Non Affiliate Participants:
SNET CBI

Owner-Client Representatives:

Owner	Fund Flag	Name	Title	Telephone #
AM	Y	D. LATTNER	AVP - TECH SVCS.	312-605-2500
BA	Y	R. ALBERS	AVP - TECH. PLNG.	703-974-8005
BS	Y	D. KETTLER	AVP - SCI.- & TECH.	404-529-2802
NX	Y	R. HELGESEN	MGR.- DIR. NTWK. PLNG.	914-683-2034
PB	Y	R. IRELAND	AVP - TECH. PLNG.	415-823-7800
SW	Y	J. CARPENTER	AVP - TECH. PLNG. & DEV.	314-235-1550
US	Y	J. CZAK	DIR.- NTWK. ARCH. & STDS.	303-889-6409

Research Tax Credit Application: