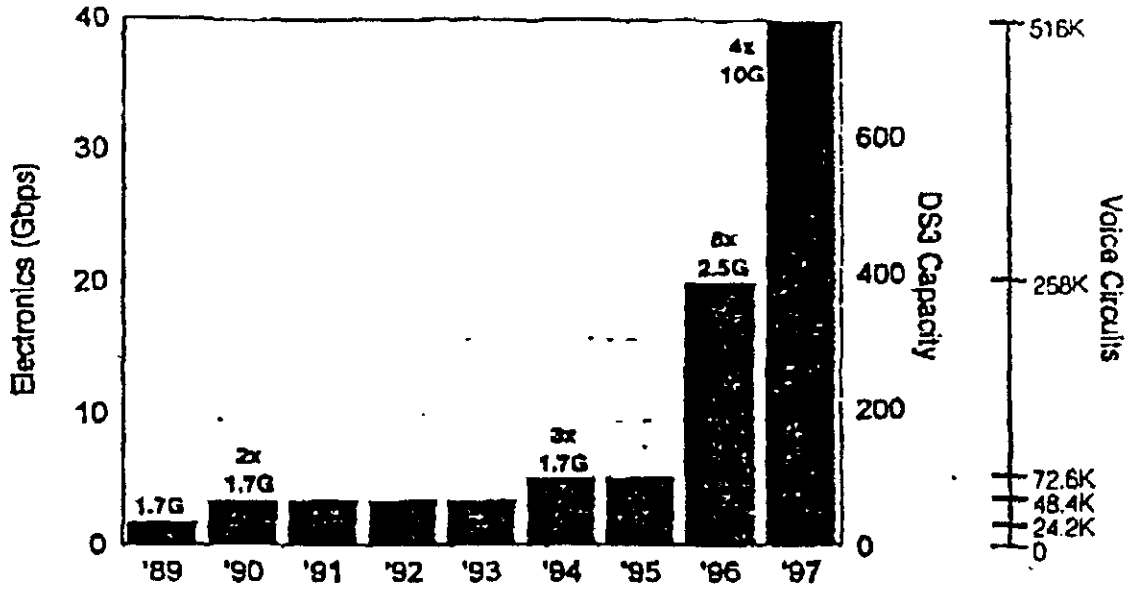
Figure 2.1 Transport Capacity Increases



Capacity increases of fiber over time

In the past, AT&T's competitors did not generally deploy the fastest possible electronics available in their networks. The following chart shows the potential fiber electronics that existed for the years 1989 through 1993, the number of corresponding DS-3s, and the average number of DS-3s per fiber pair that AT&T's competitors had deployed in their networks.[10] It is believed that the average electronics decline in 1990 may reflect the expansion of access routes with lower capacity requirements and therefore lower electronics speeds.

Table 2-1 Available Fiber Electronics Versus Average Electronics Deployed

Year	Available Electronics	# DS-3s per Fiber Pair	Average Competitor # DS-3s per Fiber Pair
1989	417 Mbps	9	10.3
	1.2 Gbps	24	
	1.7 Gbps	36	
1990	2.4 Gbps (2 x 1.2 Gbps)*	48	9.1
	3.4 Gbps (2 x 1.7 Gbps)*	72	
1991	2.4 Gbps (2 x 1.2 Gbps)*	48	12.6
	3.4 Gbps (2 x 1.7 Gbps)*	72	
1992	2.5 Gbps	48	13.2
1993	2.5 Gbps	48	16.3
1994	5.1 Gbps (3 x 1.7 Gbps)*	108	Not Available
1995	5.0 Gbps (2 x 2.5 Gbps)*	96	
1996	10 Gbps	192	
	20 Gbps (8 x 2.5 Gbps)*	384	

* - uses wave division multiplexing (WDM)

10 Derived from data in FCC "Fiber Deployment Updates" dated Apr. 1990, Apr. 1991, Apr. 1992, Apr. 1993, Apr. 1994, Johnathan M. Kraushaar

The following charts illustrate that since the 1990 Study, the actual and potential capacity installed by AT&T's competitors have grown faster than their own and the industry's switched demand. The Competitors' Transport Capacity - Growth by Component chart illustrates how increases in capacity have been largely due to faster electronics and not just the laying of new fiber in the ground. From 1990 to 1993,[11] the DS-3 capacity of AT&T's competitors has increased nearly 2.5 times, while fiber miles have only increased about 1.2 times.[12] Furthermore, the potential capacity of the existing lit fibers using the latest electronics was more than 4 times greater than the capacity of AT&T's competitors' networks at the end of 1993 as shown on the Competitor Transport Capacity - Potential & Actual chart.

The Competitors' Transport Capacity - Growth by Component chart shows that the increases in competitors' capacity have been the result of increases in three factors: electronics, fiber miles; and percentage of fiber lit. The impacts of each factor were estimated and are shown. This chart was developed by normalizing competitors' DS-3 capacity to one for 1990, the year of the prior study, and showing the contribution of each of these factors over time. The Minute Growth chart to the right shows that minutes, normalized to one in 1990 for AT&T's competitors, have grown at a slower rate than actual capacity. Industry minutes include all IXC minutes.

In order to illustrate the increasing potential capacity of the already lit fiber, the Competitors' Transport Capacity - Potential & Actual chart shows the amount of potential capacity available via re-lighting the existing lit capacity with the fastest electronics. In addition, the total amount of available capacity assuming that the fastest available electronics is used on all fibers is also shown. Competitors' DS-3 capacity is normalized to one for 1990. The Minute Growth chart to the right shows that minutes, normalized to one in 1990 for AT&T's competitors, have grown at a slower rate than capacity.

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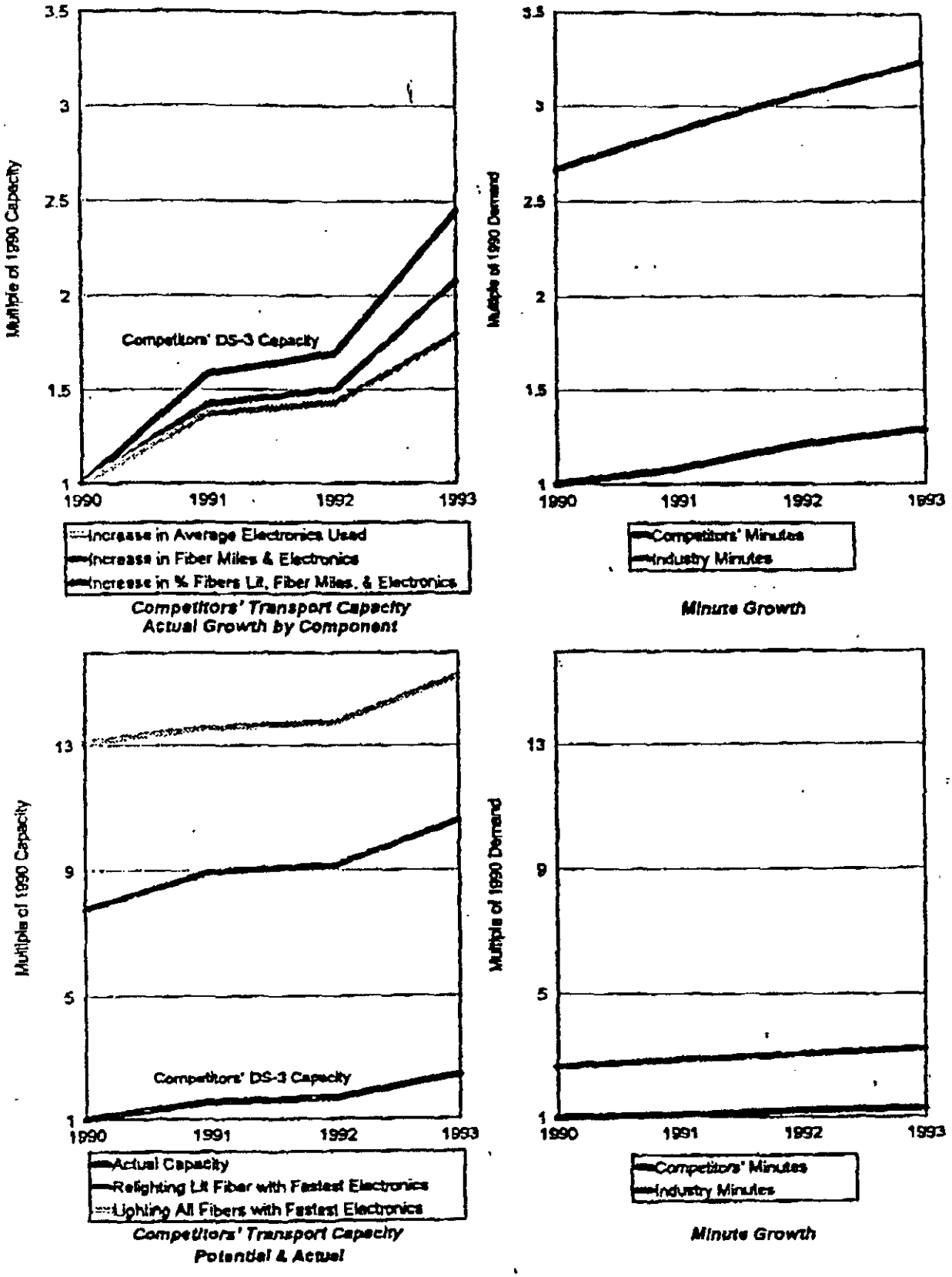
[11] In these charts, 1990 is taken as the reference point. Potential capacity is shown as a multiple of 1990 competitors' DS-3 capacity. Thus, all future values are normalized with respect to the 1990 value.

[12] Derived from data in FCC "Fiber Deployment Updates" dated Apr. 1990, Apr. 1991, Apr. 1992, Apr. 1993, Apr. 1994, Johnathan M. Kraushaar

Figure 2.2 Capacity and Demand Analysis



This analysis clearly illustrates that AT&T's competitors have enough fiber in the ground to carry many times their 1993 demand and that large increases in AT&T's competitors' network capacity could be obtained by lighting dark fibers with the latest electronics as well as upgrading the electronics on currently lit fibers. In fact, MCI and Sprint have recently announced fiber electronic upgrades using synchronous optical network (SONET) technology that will significantly increase the capacity of their networks.

MCI has stated that high speed SONET 2.5 Gbps technology was deployed in half of its network at year-end 1993, and that SONET will be available throughout MCI's domestic network by the end of 1994.[13] Recent announcements from MCI indicate that it plans to boost its transmission speed to 10 Gbps on a single fiber during 1996, and it is currently introducing new fiber optic technologies that will allow 40 Gbps transmission in 1997 or 1998.[14] In 1994, Sprint announced that in the fourth quarter of 1993 it began conversion of its entire network to 2.5 Gbps transmission speeds scheduled to be completed by mid-1996, which will double its circuit capacity.[15] Furthermore, a new technology called bi-directional coupling is now being introduced that allows each fiber to be used in both directions thereby doubling its effective capacity.

From 1990 to 1993, the available DS-3 capacity of AT&T's competitors' networks has increased nearly 2.5 times. Advances in transmission electronics have increased the capacity that a single fiber can carry from 1.7 Gbps in 1989 to 5.1 Gbps in 1994, with a promise of 20 Gbps on a single fiber in 1996 (an astonishing 12 times increase in capacity on a single fiber when compared to possible fiber capacity in 1989). Inter-exchange carriers benefit from these advances, which can increase the capacity of their networks without laying new fiber in the ground.

2.2 Switching

Advances in switching technology over the last five years have increased the maximum port capacity and call handling capability of switches. Northern Telecom Incorporated (NTI) and DSC, the major switching suppliers to AT&T's competitors in the United States, have continually updated the processors they provide with their switches as processor chip technology has advanced. Specifically, Northern Telecom's Series 20 through 40 processors use Motorola's 680x0 microprocessor technology. Northern Telecom's Series 50 through 70 use BRISC (Northern Telecom's version of reduced instruction set computing (RISC)) technology which was specifically designed for telecommunications switching applications. With RISC and the additional innovations of BRISC, the core processor of the DMS switching system accesses, processes, and transmits information more quickly and efficiently. Busy hour call attempts (BHCA) is a measure of a switch's call processing capacity. The following table and chart describes the capacity improvement that Northern Telecom has gained with each switch upgrade in relation to the Series 20 processor as measured by BHCA. This comparison is normalized to the Series 20 processor which was available in 1987.[16]

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13 "MCI Unveils Long Range Vision: networkMCI", MCI Corporate Release by Connie Weaver, Jan. 4, 1994

14 "MCI Targets Key U.S. Cities for SONET Ring Construction San Diego, Los Angeles and Houston First to Get Technology that Instantly Restores Communications if Fiber Optic Cables Are Cut", *PR Newswire*, Mar. 14, 1995

15 "Sprint Bets on SONET", *Communications Week*, Mar. 14, 1994

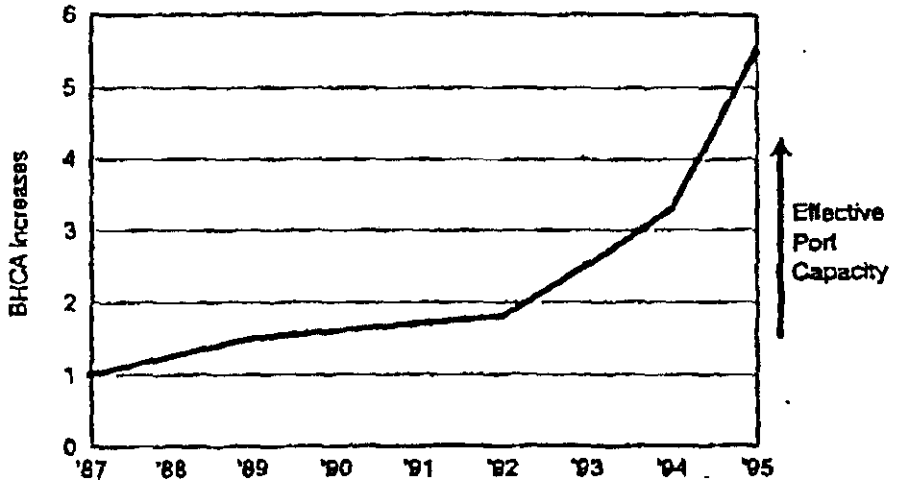
16 *DMS-100 Capacity Planner*, Aug. 1994, Issue 1

Table 2-2 Real-Time Capacity Increases of NTI Switch Processors

Year	Processor Series	Real-time Capacity (Compared to Series 20)	BHCA
1987	Supernode Series 20	1.0	300K
1989	Supernode Series 30	1.5	450K
1992	Supernode Series 40	1.8	540K
1994	BRISC Series 50	3.0	900K
1994	BRISC Series 60	3.3	990K
1995	BRISC Series 70	5.5	1,650K

A graphical depiction of the above data is shown below.

Figure 2.3 Switch Capacity Increases



Real-time capacity increases of Northern Telecom switch processors relative to Series 20 processor

DSC has also upgraded its switch processors to increase call handling capability. Its MegaHub 600E can currently handle 1.2 million BHCA.[17] By increasing the call handling capability, processor upgrades have increased the maximum effective port capacity of the switches. Northern Telecom's DMS-250 Supernode ENET and DSC MegaHub 600E upgrades increased switch capacity to 100,000 effective ports.[18]

The promise of larger switches with greater call handling capability has been realized since the 1990 Study. At present, Northern Telecom and DSC switches both provide effective port capacities of 100,000 and call handling capabilities over 1 million BHCAs. These advances in switching technology have allowed IXCs to more than meet increases in call demand by

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17 *Megahub 600E Specifications*, MegaHub 600E Tandem Switching Family of Products

18 "MCI Switch Upgrade Underway", *Communications Week*, p. 10, Feb. 18, 1991 & "MCI Starts 2-Year Switch Upgrade Program to Save Money for Itself and Users", *Communications Daily*, p. 3, Feb. 14, 1991

upgrading existing switches, which greatly exceed their present real-time switching demands, instead of by the addition of new switches to their networks.

2.3 Computing Systems for Operations and Billing

Computing workstations and mainframes are advancing in capability and function as fast, if not faster, than any other technology needed to support the telecommunications infrastructure of interexchange carriers. Since 1990, computing platforms have continued to rapidly advance and are now significantly faster, smaller, and cheaper - as well as more highly scaleable and more easily migrated to advanced system architectures such as client/server. Each year, component densities, component and system performance, bandwidths, price performance and supporting system software (e.g., operating systems) have advanced. Chip densities, for example, are roughly doubling every 18 months and will continue to do so for the foreseeable future.[19] This in turn has enabled the delivery of more powerful systems with greater feature functionality. More importantly, it has enabled the potential for rapidly expanding the capacities of telecommunications support systems, as needed, to absorb sharply increased demand.

One specific example of the improvement in computing power and price/performance since the 1990 Study is with regard to that of the Complementary Metal Oxide Semiconductor (CMOS) chip technology from Intel. With the introduction of the Pentium chip in March of 1993 the processing power of a single CMOS chip increased more than five times from the 20 million instructions per second (MIPS) of the Intel 486 chip, introduced in August of 1989, to the 112 MIPS of the Pentium.[20] At the same time the price/performance dropped from about $47.00 to $8.00 per MIPS. Similar, if not greater performance improvements have also been achieved by other chip makers, including IBM/Apple/Motorola with the PowerPC, Digital with the DECchip 21064 Alpha AXP and Sun Microsystems' SuperSPARC. In general, the trend for the chip industry over the last decade has been to increase the computational performance of the computer chip and the density of random access memory (RAM) chips roughly exponentially, as shown in the figure below.[21] Thus, dramatic improvements have been achieved in available memory and computing power since the previous study.

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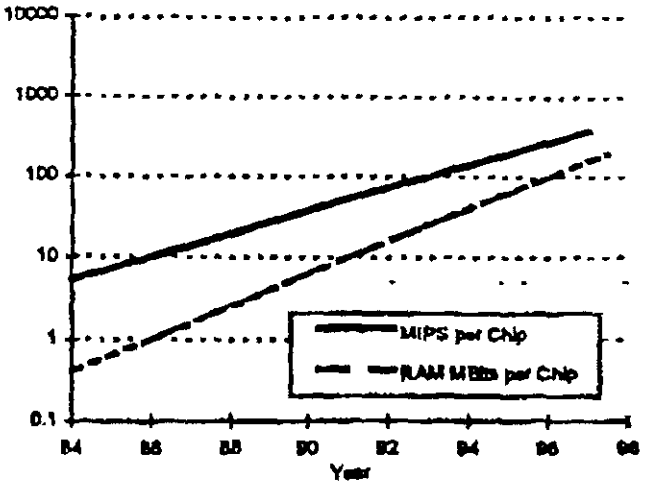
19 "The Future of Workstations", *DATAPRO Information Services*, Mar. 1992

20 "Intel Launches Rocket in a Socket", *BYTE*, pp. 99-108, May 1993

21 "The Future of Workstations", *DATAPRO Information Services*, Mar. 1992

Figure 2.4 Computing Power



Exponential growth in the power of computer chips

Computing technology improvements have also opened up a wider choice of platforms for telecommunications support systems at reduced costs. For example, while the average software application size increased by about 5 percent in 1994, the size of the largest workstation server (an alternative to mainframe systems) increased by more than 50 percent.[22] One such alternative utilizes symmetric multiprocessing (SMP), which vendors such as Hewlett-Packard claim provide a price/performance advantage of 80% or more over mainframes.[23]

In addition to the increasing number of options for support systems environments, the mainframe option has also become more attractive because mainframe power has sharply increased while prices have plummeted during the past several years since the last study. For example, the largest currently available IBM 9021 mainframe is rated at about 380 MIPS, which is more than three times the size of the largest IBM 3090 at 110 MIPS in 1990. Similar improvements in storage technology have resulted in a more than four fold increase in available capacity as IBM moved from the 3380 DASD (Direct Access Storage Device), rated at 630 Mbytes, to the 3390 DASD at 2,800 Mbytes. As a result, these rapidly declining prices have enabled even relatively low-growth IS budgets to fund a rapid increase of installed mainframe capacity. Prices have declined from $100,000 per MIPS in 1990 to $27,000 per MIPS at year-end 1994.[24] This trend is expected to continue so that by 1996 mainframe MIPS are expected to cost about $4,000, less than one twentieth of the cost at the time of the 1990 Study.[25] Also, in a parallel trend, mainframe storage capacities have greatly increased while costs per megabyte have sharply decreased. These trends are shown in the following figures.

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22 "The Mainframe Market Is Surprisingly Strong", *Inside Gartner Group This Week*, Feb. 15, 1995

23 "Mainframe Vendors Hit Hard", *Datamation*, June 15, 1994, v40, n12, p. 49

24 "The Mainframe Market Is Surprisingly Strong", *Inside Gartner Group This Week*, Feb. 15, 1995

25 "Mainframe Vendors Hit Hard", *Datamation*, June 15, 1994, v40, n12, p. 49

Figure 2.5 Mainframe Processing

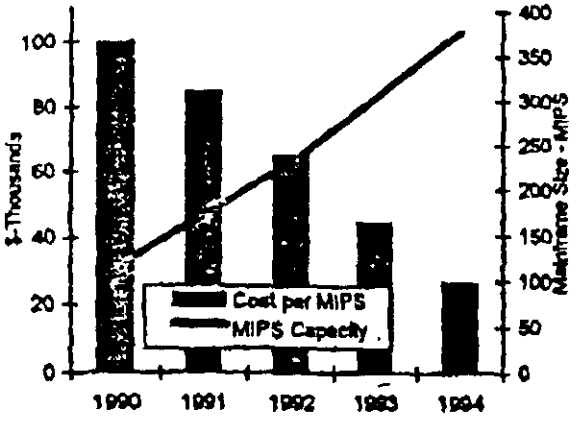
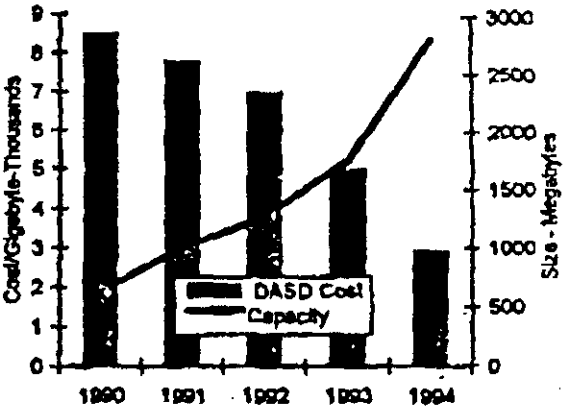


Figure 2.6 Mainframe Storage



Mainframe Technology Trends (IBM-S/390)

During the same timeframe in which prices have sharply declined and available power has increased, the mainframe has also become a more efficient business tool. This increase in efficiency is in part due to advances in networking, software and gateways which have enabled the expansion of support systems to client/server architectures while leveraging the installed base of mainframe systems. Thus while hardware and software enhancements are having a dramatic impact on the cost of mainframe systems they are also allowing legacy systems to be repositioned as corporate servers with new or expanded applications largely implemented on additional networked servers or desktops.[26] Connectivity options for tying these smaller servers to the corporate mainframes are increasingly prevalent with new operating systems such as IBM's OS/2 Warp, Microsoft's Windows NT, and UNIX from Novell. With these additional options carriers can more readily expand their support systems by adding new servers to quickly absorb rapid traffic and customer growth.

[26] "Large System Trends", *DATAPRO*, Concepts & Strategies, Apr., 1993

3. AT&T's COMPETITORS' ABILITY TO ABSORB AT&T's CUSTOMERS

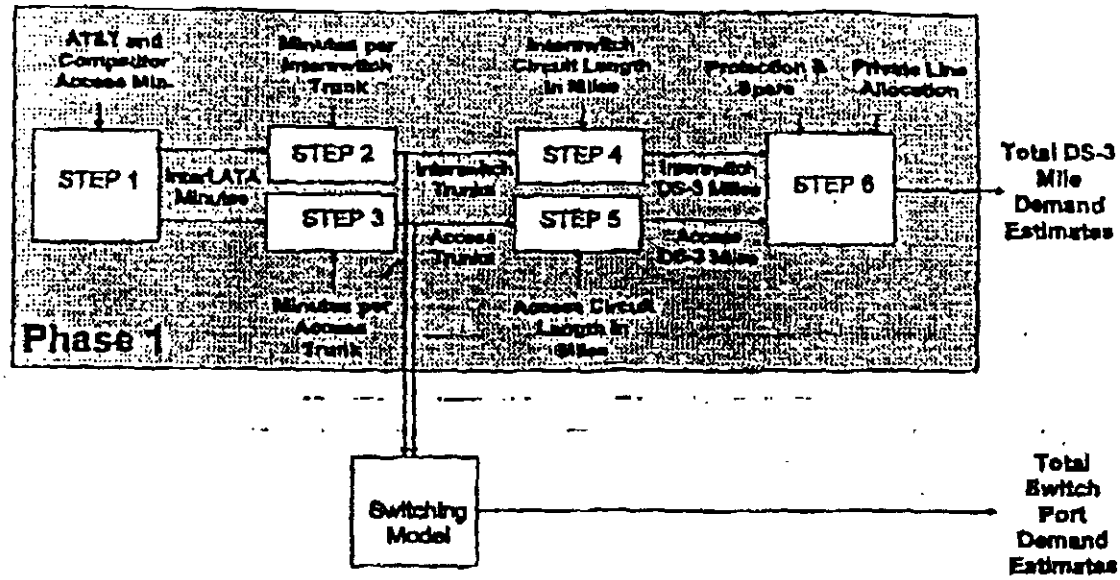
3.1 Transport Capacity Model

The objective of the transport capacity model is to determine how much of AT&T's switched and private line demand competitors could absorb over time. The model differs from the 1990 Study in that it analyzes the aggregate capacity of MCI, Sprint, and LDDS/Wiltel, whereas the 1990 study was based on the capacities of MCI and Sprint for switched services and NTN for private line. As needed, interexchange competitors have leased capacity from each other in the past and it is assumed they will do so in the future. MCI, Sprint, and LDDS/Wiltel will be referred to hereafter as AT&T's competitors. The transport capacity model estimates AT&T's and competitors' demands in phase 1, and determines the spare and potential capacity of competitors' networks in phase 2. Phase 1 estimates AT&T's and competitors' demands projected onto competitors' networks and their architectures. Minute and DS-3 circuit mile demands are estimated. In phase 2, the competitors' demands are first compared to competitors' transport capacity as reported in the FCC "Fiber Deployment Update - End of Year 1993" to determine the spare capacity that is available to absorb AT&T's demand. Next, the amount of additional capacity required to handle any remaining AT&T demand is estimated and is compared to the potential capacity of competitors' networks. Finally, estimates of the investment required by competitors' to carry AT&T's demand is determined. The latest available fiber capacity information reflecting year end 1993 data as contained in the FCC "Fiber Deployment Update - End of Year 1993" was used in the analysis.

3.1.1 Phase 1 - Demand Estimates

In phase 1, network demand measured in DS-3 circuit miles is estimated based on estimates of competitors' and AT&T's minutes. Minute demand is determined from year end 1993 data contained in the "Statistics of Communications Carriers" released by the FCC. The other inputs of minutes per trunk and circuit length were developed from the 1990 Study. Furthermore, estimates of protection capacity and DS-3 to high frequency line (i.e., fiber) packing spare capacity were developed using AT&T data. The network demand output for competitors is measured in DS-3 miles. The following flowchart provides an overview of the calculations that are described in steps 1 through 6 below.

Figure 3.1 Phase 1 - Demand Estimates



Inputs to and outputs from Phase 1 - Demand Estimates

3.1.1.1 Step 1 - Estimates of AT&T's Competitors' Total InterLATA and Access Minutes

Step 1 estimates the conversation minutes for AT&T and its competitors. First, year end 1993 data from the "Statistics of Communications Carriers Released by FCC" dated February 2, 1995 were used to estimate AT&T's and its competitors' interLATA access minutes (i.e., access plus egress minutes). Using interstate switched access minutes[27] (i.e., nodal access and egress minutes are not included) and the ratio of total industry interLATA switched access minutes to total industry interstate switched access minutes,[28] annual interLATA switched access minutes were estimated for the competitors. The following equation was used to estimate that AT&T's competitors had approximately 196 billion and that AT&T had approximately 297 billion interLATA switched access minutes.

$$\text{interLATA switched access min} = \text{interstate switched access min} \times \frac{\text{total industry switched interLATA access min}}{\text{total industry interstate switched access min}}$$

Next, the ratio of interLATA switched access minutes to total interLATA minutes was determined to account for nodal services. Note that access minutes are divided by 2 to obtain the switched access minutes that are transported on the interLATA network, since both egress and access minutes are included in the access minute total. The following equation was used to determine that the ratio of interLATA switched access minutes to total minutes is approximately 0.87.

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27 "Statistics of Communications Carriers Released by FCC", table 8.10, p. 310, Feb. 2, 1995

28 Developed from data in "Statistics of Communications Carriers Released by FCC", table 2.6, p. 22, Feb. 2, 1995

$$\text{ratio of interLATA switched access min to total min} = \frac{\text{interLATA switched access min}}{2 \times \text{total interLATA min}}$$

The total access minutes of AT&T's competitors were estimated to be approximately 225 billion using the following equation:

$$\text{total access min} = \frac{\text{interLATA switched access min}}{\text{ratio of interLATA switched access min to total min}}$$

Next, the total interLATA minutes of AT&T's competitors were estimated to be approximately 112 billion using the following equation:

$$\text{total interLATA min} = 0.5 \times \text{total interLATA min}$$

3.1.1.2 Step 2 - Estimates of Total Inter-switch DS-0 Trunks Needed to Handle the Demand of AT&T and Its Competitors

Step 2 estimates the number of inter-switch DS-0 trunks (i.e., 64 Kbps two-way channels that can carry one voice call) needed by AT&T's competitors to handle their demand and AT&T's demand based on the following assumptions:

- Calls transit either one or two switches in AT&T's competitors' networks.[29] The percentage of calls that transit only one switch was conservatively estimated to be 36% for all competitors. This represents an average of results for MCI and Sprint based on data from the 1990 Study combined with analysis of AT&T traffic data.[30]
- The 1990 Study used an estimate of 120,000 minutes per DS-0 trunk per year. More recent data suggests that trunk utilization is higher. However, a conservatively high estimate of the number of DS-0s needed by AT&T's competitors to carry existing demand was made by using the estimate of 120,000 minutes per trunk per year in the calculations.

The following equations were used to estimate that the number of inter-switch DS-0 trunks needed to handle AT&T's competitors' demand is approximately 600,000 and the number of DS-0 trunks needed to handle the equivalent of AT&T's demand on its competitors' networks is approximately 900,000. Therefore, approximately 1.5 million inter-switch DS-0 trunks would be needed to handle the demand of AT&T and its competitors on AT&T's competitors' networks.

$$\text{inter-switch trunks} = \frac{\text{total interLATA min}}{120{,}000} \times \text{fraction of minutes using 1 switch} \times 0 \text{ trunks}$$

$$+ \frac{\text{total interLATA min}}{120{,}000} \times \text{fraction of minutes using 2 switches} \times 1 \text{ trunk}$$

---

29 A small percentage of MCI's calls may go through more than two switches because part of their network is still hierarchical. Since both AT&T and Sprint have moved beyond the classical hierarchical network routing structure, it is believed that MCI either has or will shortly do so as well.

30 The 1990 Study indicated that Sprint has stated that 53% of their calls transit only one switch.

Mathematically, the first term on the right side of the equation is equal to zero, therefore the equation becomes:

$$\text{inter-switch trunks} = \frac{\text{total interLATA min}}{120{,}000} \times \text{fraction of minutes using 2 switches} \times 1 \text{ trunk}$$

3.1.1.3 Step 3 - Estimates of Total Access DS-0 Trunks to Handle the Demand of AT&T and Its Competitors

In step 3, an estimate of access trunk utilization is used to estimate the number of access DS-0 trunks that are needed to handle the demand of AT&T and its competitors. access DS-0 trunk utilization is estimated to be 96,000 minutes per trunk per year (i.e., 80% of 120,000 minutes per inter-switch trunk per year). This was compared to AT&T's data and is believed to be conservative for AT&T's competitors. Total access minutes are divided by this estimate to determine the number of access DS-0 trunks that are needed by AT&T's competitors to handle the demand of AT&T and its competitors.

The following equation was used to estimate that the number of access DS-0 trunks needed to handle AT&T's competitors' demand is approximately 2.3 million and the number of access DS-0 trunks needed to handle AT&T's demand is approximately 3.5 million. Therefore, the total number of access DS-0 trunks needed by AT&T's competitors to handle AT&T's and their own demand is 5.8 million.

$$\text{access trunks} = \frac{\text{total access min}}{96{,}000}$$

3.1.1.4 Step 4 - Estimates of Total Inter-Switch DS-3 Circuit Miles Needed to Handle the Demand of AT&T and Its Competitors

Step 4 estimates the inter-switch DS-3 circuit miles needed to handle the demand of AT&T and its competitors. The average inter-switch DS-0 trunk length of AT&T's competitors is derived from results of the 1990 Study as a basis for this model's assumptions. The 1990 Study assumed that if a switching location (i.e., a building) contained more than one switch, calls between local exchange carrier (LEC) central offices homed on different IXC switches within the building required an inter-switch trunk. Based on an updated understanding of industry engineering practices, this model assumes that all IXC switches within a building have access trunks which go to all LEC central offices served by that switching location, either directly or via an access tandem. This assumption eliminates the unnecessary inter-switch trunks of essentially zero length between switches at the same location. Therefore, the inter-switch trunk lengths for this model were determined to be 1,705 miles for MCI and 1,621 miles for Sprint. Averaging these two together, we assume an inter-switch trunk length of 1,663 miles for AT&T's competitors.[31] All other assumptions from the 1990 Study relating AT&T's competitors' switching locations and coverage of service are used in this model.

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[31] These inter-switch trunk lengths are longer then those contained in the 1990 Study. That study included inter-switch trunks between switches in the same location which would have essentially zero length since they were intra-building.

The following equation was then used to determine the total inter-switch DS-3 circuit miles needed by AT&T's competitors to handle the demand of AT&T and its competitors. A packing efficiency of 0.85 was used to estimate the number of DS-0 channels that are utilized in a DS-3 channel. The number of inter-switch DS-3 circuit miles needed to handle AT&T's competitors' demand was determined to be approximately 1.7 million. The number of inter-switch DS-3 circuit miles needed to handle AT&T's demand was determined to be approximately 2.6 million. Therefore, the number of inter-switch DS-3 circuit miles needed to handle the demand of AT&T and its competitors is approximately 4.3 million.

$$\text{inter-switch DS-3 circuit miles} = \frac{\text{inter-switch DS-0 trunks} \times \text{competitor inter-switch trunk length}}{672 \text{ DS-0s per DS-3} \times \text{packing efficiency}}$$

3.1.1.5 Step 5 - Estimates of Access DS-3 Circuit Miles Needed to Handle the Demand of AT&T and Its Competitors

Step 5 estimates the total access DS-3 circuit miles needed to handle the demand of AT&T and its competitors. This model uses assumptions from the 1990 Study to estimate the average access trunk length of AT&T's competitors and the fraction of access trunks that must leave the switching location to interface with the LEC (some access trunks interface to the LEC at a point of presence (POP) in the same building and would therefore have essentially zero length). The following access trunk additions were reported in the 1990 Study:[32]

- Sprint required 878,000 access DS-0 trunks with outside facilities (i.e., those that go to POPs external to the switching location) having an average length of 169 miles. The total number of access DS-0 trunks with and without outside facilities was 1,240,000.
- MCI required 341,000 access DS-0 trunks with outside facilities having an average length of 116 miles. The total number of access DS-0 trunks with and without outside facilities was 919,000.

This information was used in the following equations to estimate the average access trunk length of AT&T's competitors and the fraction of access trunks with facilities (i.e., those that leave the switching location to interface with the LEC) for these competitors. It is assumed that the average length of an access trunk with a facility is equal to the average of MCI's and Sprint's lengths. Further, it is also assumed that the competitors' fraction of access trunks with facilities is equal to the average of the 1990 Study fractions determined for MCI and Sprint. The average access trunk length of AT&T's competitors was determined to be approximately 143 miles and the fraction of access trunks with facilities was determined to be approximately 0.54.[33]

$$\text{average competitor access trunk length} = \frac{169 + 116}{2}$$

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[32] The access trunk mileage calculations based on the 1989 data used for the 1990 Study will produce conservatively long access trunks because they do not take into account AT&T's competitors' initiatives to reduce access charges, like the relocation and addition of points-of-presence and local deployment such as MCI Metro.

[33] MCI and Sprint have increased their number of POPs since the 1990 Study. This would increase DS-3 access circuit miles by increasing the fraction of access trunks with facilities within a LATA. However, competitors can still lease facilities from the LECs, as in the past, to meet this demand.

$$\text{fraction of access trunks with facilities} = 0.5 \times \left[\frac{878{,}000}{1{,}240{,}000} + \frac{341{,}000}{919{,}000} \right]$$

The following equation was then used to estimate the total access DS-3 circuit miles needed by AT&T's competitors to handle the demand of AT&T and its competitors. A packing efficiency of 0.85 was again used to estimate the number of DS-0 channels that are utilized in a DS-3 channel. The number of access DS-3 circuit miles needed to handle the demand of AT&T's competitors was estimated to be approximately 0.3 million. The number of access DS-3 circuit miles needed to handle AT&T's demand was estimated to be approximately 0.5 million. Therefore, the number of access DS-3 circuit miles needed to handle the demand of AT&T and its competitors is approximately 0.8 million.

$$\text{access DS-3 circuit miles} = \frac{\text{access DS-0 trunks} \times \text{fraction of trunks with facilities} \times \text{average competitor access trunk length}}{\text{672 DS-0s per DS-3} \times \text{packing efficiency}}$$

3.1.1.6 Step 6 - Estimates of Total DS-3 Circuit Miles Needed to Handle the Demand of AT&T and Its Competitors

Step 6 estimates the total DS-3 circuit miles needed to handle the demand of AT&T and its competitors. The total DS-3 circuit miles are scaled up to account for private line services, as well as protection, restoration and breakage (i.e., spare) when grouping DS-3 circuits onto high frequency lines (i.e., fiber). The factors used are consistent with MCI's modeled demand to reported capacity and AT&T data. It was determined by the following equation that the total DS-3 circuit miles needed by AT&T's competitors to handle their own demand is approximately 3.8 million and that the total DS-3 circuit miles they will need to handle AT&T's demand is approximately 7.4 million, for a total of approximately 11.2 million DS-3 circuit miles needed to handle the demand of AT&T and its competitors.

$$\text{total DS-3 circuit miles} = \frac{\text{inter-switch DS-3 circuit miles} + \text{access DS-3 circuit miles}}{\text{fraction of in-service to total DS-3s} \times \text{private line factor}}$$

The total DS-3 circuit miles needed to carry AT&T's competitors' demand is approximately 3.8 million and the currently lit total DS-3 mile capacity in AT&T's competitors networks is 7.4 million.[34] Therefore, approximately 3.6 million DS-3 miles were already lit at the end of 1993 and available to handle nearly 50% of the 1993 AT&T switched and dedicated demand. It should be noted that this does not take into consideration any of the capacity available on AT&T's competitors' microwave facilities, so the actual DS-3 miles already in place is a larger number.

3.1.2 Phase 2 - Capacity and Demand Comparison

Phase 2 compares competitors' estimated demand to their transport capacity reported in the FCC "Fiber Deployment Update - End of Year 1993" to estimate the available in-place spare capacity available to absorb a portion of AT&T's demand. Further, when AT&T's demand is

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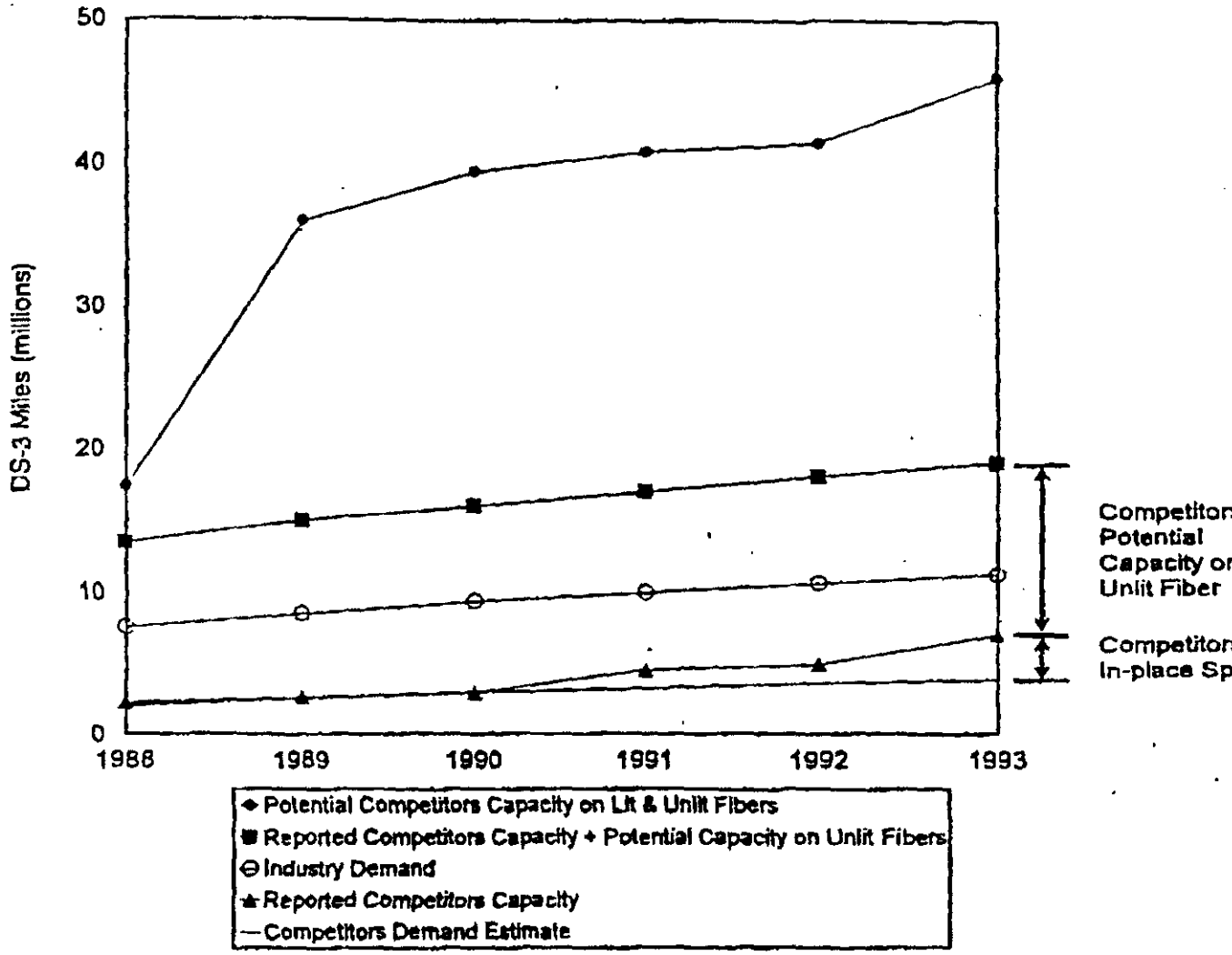
[34] Derived from data found in the FCC "Fiber Deployment Update - End of Year 1993", Johnathan M. Kraushaar

placed on competitors' networks, the in-place spare capacity is consumed and a portion of the potential capacity from new electronics on existing dark (i.e., unlit) fiber is used. The results are shown in the following chart.

Figure 3.2 Capacity and Demand Summary



Capacity and demand over time

These results indicate that AT&T's competitors' DS-3 capacity on lit fibers has grown faster than the DS-3 demand estimate required to handle their minute growth. The estimated competitors' capacity combined with the potential capacity on unlit fibers is about 1.7 times the industry DS-3 demand in 1993. In fact, the potential capacity of lit and unlit fibers in competitors' networks is four times the industry DS-3 demand in 1993. The advances in transmission technologies have clearly eliminated transport as a limiting factor for competitors' growth in the industry.

3.2 Transport Capacity Results

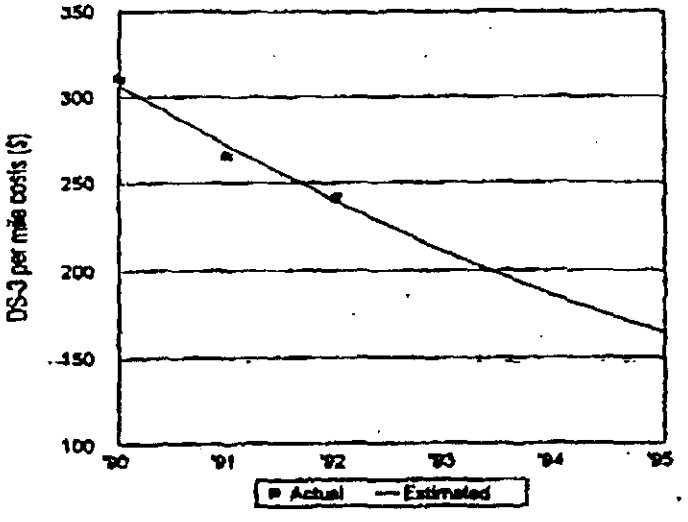
The total DS-3 circuit miles needed to carry AT&T's competitors demand is approximately 3.8 million and the lit total DS-3 mile capacity in AT&T's competitors' networks is 7.4 million. Therefore, approximately 3.6 million DS-3 miles are already lit and available to carry AT&T's demand. Given that 7.4 million DS-3 circuit miles are needed to carry AT&T demand, AT&T's competitors need to light an additional 3.8 million DS-3 miles to handle all of AT&T's demand. This information is summarized in the following table.

Table 3-1 Total DS-3 Circuit Miles Required

Demand Estimates	Required DS-3 Circuit Miles	Available DS-3 Circuit Miles	Excess DS-3 Circuit Miles
Competitors	3.8 M	7.4 M	3.6 M
AT&T	7.4 M		
AT&T + Competitors	11.2 M	7.4 M	-3.8 M

The following assumptions were made to estimate the cost of adding the additional DS-3 miles to AT&T's competitors' networks. The investment required to light existing fibers with electronics was estimated using the FCC "Fiber Deployment Updates" for the years 1990 through 1992. Based on the trend that is observed when the DS-3 per mile investment data is plotted, a cost of $185 per DS-3 mile was used as representative of current electronics costs. This compares well with the investment that Sprint reported to the FCC for 1992 of $215 per DS-3 mile.[35]

Figure 3.3 DS-3 Mile Cost Estimates



Cost per DS-3 mile

In addition to electronics costs, a cost of $50 per DS-3 circuit mile, believed to be very conservative, will be used to estimate competitors' digital cross connect (DCS) costs. Therefore,

35 "Fiber Deployment Update - End of Year 1992", Johnathan M. Kraushaar, p. 8, table 4

the total incremental cost of lighting existing fiber with the fastest electronics available and adding digital cross connects is estimated to be $235 per DS-3 mile.

The cost of adding digital cross connects to competitors' networks to utilize the fiber that is already lit, but not in use on competitors' networks, is approximately $180 million. The cost of adding 3.8 million DS-3 miles on existing dark fiber with transport electronics and DCS equipment to competitors' networks is approximately $893 million. Therefore, the new transport investment required by competitors is approximately $1,073 million. These findings are summarized in the following table.

Table 3-2 New Transport Investment Required by Competitors

Demand Estimates	DS-3 Circuit Miles Required		New Transport Investment
	Incremental	Cumulative	
Competitors' on existing lit fiber	-	3.8 M	None
+ AT&T's on existing lit fiber	3.6 M	7.4 M	$180 M
+ AT&T's on existing dark fiber	3.8 M	11.2 M	$893 M
Total	7.4 M	11.2 M	$1,073 M

3.3 Switching Model

The switching model uses the estimated inter-switch DS-0 trunks and access DS-0 trunks from the transport capacity model to determine the number of new switch ports that must be added to AT&T's competitors' networks to handle the demand of AT&T and its competitors. The number of new switches, if any, that need to be added to AT&T's competitors' networks are also determined. The model examines only the switches currently in MCI's, Sprint's and LDDS/Wiltel's networks as a subset of the total number of all AT&T's competitors' switches, believed to be in excess of 250. The costs associated with new switch ports, new echo cancellers, and new switches, if any, are also determined.

The transport capacity model assumed that AT&T's competitors' inter-switch DS-0 trunks can handle 120,000 minutes per year and that their access DS-0 trunks can handle 96,000 minutes per year. Every inter-switch trunk requires two switch ports, and every access trunk requires one switch port. These assumptions and the number of trunks from the network capacity model are used in the following equation to estimate the number of additional switch ports that are needed in AT&T's competitors' networks to handle AT&T's demand.

total switch ports = (inter-switch DS-0 trunks x 2 ports) + (access DS-0 trunks x 1 port)

The number of switch ports needed by AT&T's competitors to handle their demand is approximately 3.5 million and the number of switch ports they would need to handle AT&T's demand is approximately 5.4 million, for a total of approximately 8.9 million switch ports needed by AT&T's competitors to handle their own and AT&T's demand. The results are summarized in the following table.

Table 3-3 Total Switch Ports Required

Demand Estimates	Switch Ports Required
Competitors	3.5 M
AT&T	5.4 M
AT&T + Competitors	8.9 M

It is assumed that two echo cancellers are required on every inter-switch DS-0 trunk (i.e., one for each end). Therefore, the number of inter-switch DS-0 trunks from the transport capacity model is multiplied by 2 to determine the number of DS-0 echo cancellers needed to handle the demand of AT&T and its competitors. The findings are summarized in the following table:

Table 3-4 Total Echo Cancellers Required

Demand Estimates	Required Echo Cancellers
Competitors	1.2 M
AT&T	1.8 M
AT&T + Competitors	3.0 M

MCI has a total of 80 Northern Telecom Incorporated (NTI) DMS-250 Supernode ENET and DSC's DEX MegaHub 600E switches in its domestic network. Sixty of these switches were upgraded between 1991 and 1993, and the entire network was upgraded by 1994.[36] Further, it is assumed that all 45 of Sprint's DMS-250 Supernode switches have the ENET upgrade.[37] LDDS/Wiltel uses DSC's switches in its network: 8 DMS-250 Supernodes, 6 DEX MegaHub 600Es, 11 DEX 600s, and 16 DEX 400s.[38] The number of switches per carrier is summarized in the following table:

Table 3-5 Competitors' Switches

Switch Type	MCI	Sprint	LDDS/Wiltel	Total
NTI DMS-250 Supernode ENET DSC MegaHub 600E	80	45	14	139
DSC 600			11	11
DSC 400			16	16

The ENET upgrade to the NTI DMS-250 Supernode boosts its effective traffic carrying port capacity to 100,000.[39] The DSC MegaHub 600E has an effective capacity of 100,000 ports.[40] The maximum effective capacity on the DSC 600 is 30,000 ports and on the DSC 400 is

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36 "MCI Switch Upgrade Widens Service Options for Users", *Network World*, p. 2, Feb. 18,1991 & " MCI Starts 2-Year Switch Upgrade Program to Save Money for Itself and Users", *Communications Daily*, p. 3, Feb. 14, 1991

37 *Faulkner's Telecommunications Strategies, Converging Technologies and Trends, Sprint*, p. 8, Dec. 1994

38 *LDDS Metromedia presentation*, Technical Services Department Presentation to the Regional User Group Forum, Nashville, Tennessee, Aug. 18, 1994

39 "MCI Switch Upgrade Underway", *Communications Week*, p. 10, Feb. 18, 1991

40 "MCI Starts 2-Year Switch Upgrade Program to Save Money for Itself and Users", *Communications Daily*, p. 3, Feb. 14, 1991

14,300 ports.[41] The current maximum claimed effective DS-0 port capacity for each switch is summarized in the following table:[42]

Table 3-6 DS-0 Ports per Switch

Switch Type	Maximum Port Utilization	Maximum Physical Ports
NTI DMS-250 Supernode ENET	100 K	128 K
DSC MegaHub 600E	100 K	131 K
DSC 600	30 K	32 K
DSC 400	14 K	16 K

The switching model assumes that all the switches in MCI's and Sprint's networks have been upgraded and can handle 100,000 ports. For LDDS/Wiltel, the switching model assumes that the NTI DMS-250 Supernode and the DSC DEX MegaHub 600Es can handle 100,000 ports, the DSC DEX 600s can handle 30,000 ports, and the DSC DEX 400s can handle 14,300 ports. Therefore, the maximum number of MCI, Sprint and LDDS/Wiltel ports available is 14.4 million. The maximum number of effective switch ports available to AT&T's competitors switches under consideration was calculated based on the above information and is summarized in the following table:

Table 3-7 Maximum Effective Switch Ports Available per Competitor

Switch Type	MCI	Sprint	LDDS/Wiltel	Total
NTI DMS-250 Supernode ENET or DSC DEX MegaHub 600E	8.0 M	4.5 M	1.4 M	13.9 M
DSC DEX 600			.3 M	.3 M
DSC DEX 400			.2 M	.2 M
Total	8.0 M	4.5 M	1.9 M	14.4 M

3.4 Switching Results

Since only 8.9 million switch ports are needed to handle the demand of AT&T and its competitors, and the maximum switch port capacity of MCI, Sprint and LDDS/Wiltel switches combined is 14.4 million, no new switches would be needed in their networks. In fact, their existing switches would only be 62% full, leaving 38% of maximum effective switch port capacity for future growth and geographical variations and load. It should also be noted that the effective switch ports capacities will increase as switch processor BHCA increases.[43]

If we eliminate LDDS/Wiltel's switches from the analysis, and only consider the switches in MCI's and Sprint's networks, the maximum switch port capacity of MCI and Sprint is 12.5 million. This is still well above the 8.9 million switch ports that are required to handle the

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41 *Megahub 600E Specifications*, MegaHub 600E Tandem Switching Family of Products

42 The maximum system ports on DSC MegaHub 600E switch is 131,072 of which 119,040 ports can be used for traffic. (*Megahub 600E Specifications*, MegaHub 600E Tandem Switching Family of Products) The Northern Telecom DMS-250 Supernode ENET switch has a maximum capacity of 128,000 ports. (*DMS-250 Product Description*, Northern Telecom, pp. 49-53, Dec. 1993) It is assumed that the DMS-250 can have a similar percentage of ports is available for traffic as the DSC MegaHub 600E, resulting in 116,250 ports. However, both manufacturers do not recommend exceeding 100,000 effective ports per switch.

43 As described in Industry and Technology Trends - Switching section of this document.

demand of AT&T and its competitors. MCI's and Sprint's switches would be approximately 71% filled, and still have approximately 29% of maximum effective switch port capacity remaining for future growth.

The costs of adding the 5.4 million switch ports and 1.8 million echo cancellers to AT&T's competitors' networks was estimated as follows. Switch ports are estimated to cost $150 per port. Echo cancellers are estimated to cost $90 each per inter-switch DS-0 trunk end.[44] The total investment for adding the 543 million additional switch ports is approximately $810 million. The total investment for adding the 1.8 million additional echo cancellers is approximately $162 million. Therefore, AT&T's competitors would need to invest approximately $972 million in switching equipment to handle all of AT&T's demand. The results are summarized in the following chart.

Table 3-8 New Switching Investment Required by Competitors

Switching Results	New Investment
Switch ports	$810 M
Echo cancellers	$162 M
Total new investment	$972 M

3.5 Signaling Model

The signaling network model used for this study is similar to that used in the 1990 Study. However, it was updated to reflect current signaling network parameters. In particular, the trunk setup message lengths were increased to a conservative 45 bytes from 25 bytes, and the database message lengths were increased to 125 bytes from 75 bytes and the average call holding time was reduced from 5 minutes to a more conservative 3 minutes. In addition, the signaling links were assumed to operate at 40% of their capacity in conformance with current engineering practice and additional switch to alternate STP region links (i.e., E-Links) were included for network reliability, as compared to 30% in the 1990 Study with no E-Links.

The signaling network is sized in this model based on demand, STP link and processor capacity, switched network capacity and network architecture. As in the switching model, the signaling model only studied the capacities of MCI, Sprint, and LDDS/Wiltel. The same competitors' demands and allocations of AT&T's demand were used as in the switching model.

The signaling model estimates the incremental cost requirements in three steps. First, in the base case, the signaling network is sized to accommodate the current level of usage in each of AT&T's competitors' networks. This estimates the STP capacity currently used in the MCI, Sprint and LDDS/Wiltel networks. The second step determines the signaling network size required for the projected demand, which adds the AT&T call load level from the switched network model. The final step calculates the amount and cost of the new equipment needed to carry the projected demand by subtracting the existing equipment from what is needed to support the projected total demand.

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[44] Switch port and echo canceller costs were based on information from manufactures.

Two signaling message types are modeled; a trunk setup message and a database query message. The setup of a trunk is assumed to generate six messages of 45 bytes each and all calls that require a database query generate two 125 byte messages to be carried by the network. The cost and capacity needed were conservatively overestimated for this, by assuming that only 30% of calls in each competitor's existing demand require a database query, while for the projected case, 50% of all calls (including the competitors' and AT&T's calls) require a database query.

The model is based on full signaling network interconnection of competitors with the local exchange carriers (LECs). Furthermore, LDDS/Wiltel, Sprint, and MCI are assumed to interconnect with the LECs so that a signaling point of interface (SPOI) is established in each LATA they serve. The 1990 Study data was used for SPOIs. Sprint had a total of 186 SPOIs nationwide, while MCI and LDDS/Wiltel each had a total of 174 SPOIs. Also, while trunk setup messages are transmitted between the LEC and IXC STPs, it is assumed that no database queries cross the SPOI boundary.

The switching model results show that no additional switches are needed by LDDS/Wiltel, Sprint or MCI to serve all of AT&T's switched service customers. Therefore, the model is based on 45 switches for Sprint, 80 switches for MCI and 41 switches for LDDS/Wiltel in both the base demand scenario and the projected demand scenario. In addition, since Sprint has publicly stated that its switches are fully and directly interconnected, for simplicity, the model is based on all calls passing through two Sprint switches.[45] The same assumption is made for MCI and is therefore very conservative as discussed in the switching model.

The model converted from annual minutes of use to busy-hour signaling messages in order to design each signaling network based on busy hour signaling message demand. The annual minutes of use were converted to daily minutes by dividing by 264 (22 business days per month and 12 months per year). The minutes of use were converted to number of calls by assuming a 3 minute average holding time. The model then converted to calls per busy hour by multiplying by 0.1, since studies show that less than 10% of the daily calling load occurs during the busy hour. Also, calling traffic was assumed to be uniformly distributed among the switches.

After the busy hour calling load was calculated, the model was used to determine the average number of signaling messages per switch in the busy hour. Next, the number of switch-to-STP links (A links & E links), SPOI-to-STP links, STP-to-STP links and Database-to-STP links are calculated assuming the standard engineering practice of 40% occupancy rate for each of the 56,000 bits per second links. Finally, these links were distributed by the model among the STPs in the network.

The signaling links were aggregated to find the total number of links per STP required to carry the message demand. When this number of links was greater than 75% of the total link capacity of an STP, the model added a new pair of STPs and re-calculated link requirements

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[45] In a September 1988 presentation to the National Communications Forum, Sprint stated that 53% of its calls require only one switch. To conservatively overestimate the equipment needed, however, this model assumes two switches per call.

with the new network configuration. Thus, the model added new STP pairs until the STPs were loaded to no more than 75% of their capacity. The STPs used in this model were assumed to have a full capacity of 720 links (that of the DSC DEX STP used by both MCI and Sprint). This is the same capacity used for the 1990 Study and is considered to be even more conservative now.

The cost of the signaling network was determined in the final step of the model. This was determined from the amount of additional signaling equipment, including STPs, signaling links and facilities, needed to support the projected demand scenario. As in the 1990 Study, new STPs are assumed to cost $5 million per pair, while signaling links cost $900 per link for terminations and provisioning and $0.661 per mile for transmission facilities and multiplexing. These costs are conservatively high. The average link length was assumed to be equal to the average inter-toll trunk length in each carriers network.

3.6 Signaling Results

The signaling model results show that four additional STP pairs are needed by MCI at a cost of $20 million. In addition, the signaling link termination, transmission facility and provisioning costs for MCI equal $8.3 million. The total new investment in signaling required by MCI is $28.3 million.

For Sprint, two additional STP pairs are needed at a cost of $10.0 million. The additional signaling link termination, transmission facility and provisioning costs for Sprint equal $4.8 million. The total new investment in signaling required by Sprint is therefore $14.8 million.

One additional STP pairs is needed by LDDS/Wiltel at a $5 million cost. The required signaling link termination, transmission facilities and provisioning costs for LDDS/Wiltel equal $2.1 million. The total new investment in signaling required by LDDS/Wiltel is therefore $7.1 million.

Summing the new signaling investment required by these AT&T competitors to handle AT&T's demand produces a total of $50 million, as described in the following table:

Table 3-9 New Signaling Investment Required by Competitor

Competitor	Additional STP Pairs	STP Investment	Termination, Provisioning, & Facility Investment	Signaling Investment
MCI	4	$20 M	$8.3 M	$28.3 M
Sprint	2	$10 M	$4.8 M	$14.4 M
LDDS/Wiltel	1	$5 M	$2.1 M	$7.1 M
Total	7	$35 M	$15.2 M	$49.8 M

These conservatively high estimates show that signaling capacity growth is not a limiting factor in the rate at which competitors can absorb AT&T's customers, nor is it a significant component of the investment required.

3.7 Network Intelligence Model

The network intelligence model studied the capacity of MCI, Sprint, and LDDS/Wiltel to perform centralized database translations in support of switching (e.g., 800 number translations). The database architecture of Sprint, MCI and LDDS/Wiltel are considered to be highly and easily scaleable, so that, several options are available to these carriers to absorb additional traffic demands. They can readily add capacity to existing database locations or add new databases in new locations to satisfy their needs. This is especially true for the Tandem architecture of Sprint and that of the DEC VAX cluster architecture in MCI's network.

Because of the scaleability of the carriers' database architecture, and the diverse number of possible architectural solutions, the model estimates the additional database equipment needed without modeling the details of the database architecture. To estimate the database costs, the model determines the additional number of database transactions per second and uses a typical cost per transaction per database to calculate costs.

The number of transactions per second needed in each network was determined from the number of busy hour calls from the signaling model multiplied by the fraction of calls requiring a database transaction. Then, the model used the cost per additional transaction per second of $30,000 from the 1990 Study to calculate the total additional database cost. The $30,000 per transaction estimate is conservatively high because of the industry's advances in this area and the resulting decrease in technology costs since the 1990 Study.

3.8 Network Intelligence Results

The network intelligence model shows that an increase in database loading requires an additional $63.0 million of database equipment for MCI, an additional $37.1 million of database equipment for Sprint, and an additional $17.3 million of database equipment for LDDS/Wiltel. Summing together the database investment required by these AT&T competitors to handle AT&T's demand produces a total of $114.4 million, as described in the following table:

Table 3-10 New Database Investment Required by Competitor

Competitor	Additional Transactions per Second	Database Investment
MCI	2,100	$60.0 M
Sprint	1,236	$37.1 M
LDDS/Wiltel	575	$17.3 M
Total	3,911	$114.4 M

These very conservative database results show that network intelligence capacity growth is not a limiting factor in the ability of AT&T's competitors to quickly absorb AT&T's customers. Also, it is not a significant component of the total investment required.

3.9 Billing Model

The 1990 Study found that "the billing environment of either MCI or Sprint could be significantly expanded to effectively support rapid demand growth. Further, billing systems would not impose limitations on a competitor's strategy to make use of its additional network capacity." What was demonstrated in the 1990 Study is even more true today. Computers, which are the primary drivers of billing capabilities, have increased in processing power at a rate that has been faster than the growth in telecommunications demand. Millions of Instructions Per Second (MIPS), a standard measure of computing power, has increased at a rate nine times faster than minutes of use on AT&T's network. The introduction of new billing capabilities to meet the highly competitive market demands of the long distance business use some of this processing power, but computer hardware and software advances have significantly exceeded the new processing demand of the billing environment. In addition, numerous outsourcing opportunities are available to support large capacity billing needs, as illustrated by Sprint's negotiations with EDS to handle its billing and other data processing operations and the industry's use of the billing capabilities of the LECs.[46]

The billing model takes the same approach used in the 1990 Study, updating and extending it to an overall industry view. This approach takes AT&T's traffic and accounts, and allocates them among MCI, Sprint and LDDS/Wiltel based on available switch port capacity. Although only MCI, Sprint and LDDS/Wiltel are studied in this model, the results will apply to the aggregate of all competitors. AT&T's Business and Residence accounts have been held at the 1990 Study volume level.

The billing model estimated the resources that would be required by AT&T's competitors to bill the accounts and volumes of domestic and international public switched network services absorbed from AT&T. It developed one estimate for basic Long-Distance Service (LDS) and one for the in-bound (800 service) and out-bound (WATS and other high-volume business-oriented services) families of non-LDS services. The model first converts annual minutes to daily minutes by dividing by 264 (22 business days per month and 12 months per year) and then converts from minutes to calls based on an average call length of 5 minutes. The absorption of customers is modeled in equal monthly increments, and the estimates of the additional hardware and software requirements are based on standard industry processing capabilities. The additional human resources required to operate the expanded billing system and the associated support functions, such as payroll processing, are included in the human resources model.

The billing system requires an Automated Message Accounting (AMA) System, a Message Processing Systems (MPS), and an Account Billing System (Biller). The processing capacities assumed for these systems are based on current industry standard technological capabilities. The AMA system can process 60 million messages per day per copy and distribute the corresponding data to an MPS. An MPS can process ten million LDS messages - or 45 million non-LDS messages - per copy per day. One copy of a Universal Message Investigation System is provided for each MPS. A Biller can process 11 million LDS residential accounts, 3 million LDS or non-LDS low-end business accounts, or 500,000 non-

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[46] *Business Week*, June 20, 1994.

LDS high-end business accounts per copy per day. If multiple system copies of a AMA system MPS and/or Biller are required, standard industry software would be used to direct data from the AMA to the appropriate copy of the MPS, and then to the Biller managing a specific account. The number of additional copies of each of these systems is determined by translating the growth in volume to daily processing requirements. The study used 264 processing days per year for these calculations. Also, because account and volume growth were modeled in geographically uniform equal monthly increments, all required copies of the Biller are modeled as operational as soon as accounts begin to migrate. All accounts will be put into the proper database immediately, thereby eliminating the need for any later database reorganization.

The study assumes that the operating system is an IBM MVS using standard software products (e.g., MVS, JES, COBOL, IMS/DB2), and that AT&T's major competitors have an operational system in one central location or outsource their billing requirements. It is assumed that AT&T's competitors will lease or purchase the latest state of the art processors, IBM 9021/982s or equivalent. The required number of IBM 9021/982s is determined based on the computer's processing capacity and on the growth in data-processing requirements. Ten million messages per MPS copy per day would require 3.8% of an IBM 9021/982. One million business accounts would require 44.2% of an IBM 9021/982 without usage processing. Ten million residential accounts would require 55% of an IBM 9021/982 without usage processing. If the additional processing capacity described above necessitates the establishment of an additional data center, this should not cause an implementation delay. New computer-ready facilities are available in the current real estate market. Hardware is available from IBM and Amdahl for delivery within 60 days from order, and it can be operational within another 60 to 90 days. Staff availability and expertise should not be a constraint because, if necessary, the services of a third-party vendor, such as EDS or the LECs, could be obtained.

Each residence customer is modeled to have one account and only LDS service. Business customers may have multiple accounts and both LDS and non-LDS services. These customer profiles were used for all of AT&T's competitors.

3.9.1 Basic LDS Billing

The additional LDS accounts and messages, and the additional systems that AT&T's competitors would require to absorb AT&T's customers are as follows:

Table 3-11 Additional LDS Systems Required by Competitors

System	Daily Processing per Copy	Additional Activity	Copies Needed
AMA	60 M Messages	49.9 M Messages	1
MPS	10 M Messages	49.9 M Messages	5
Residential biller	11 M Accounts	86.3 M Accounts	8
Business biller	3 M Accounts	3.9 M Accounts	2