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Converging Industries Research Foundation

Practical Solutions for Communications Policy

Schools in Cyberspace: The Cost of Providing Broadband Services to Public Schools

July 1, 1995

Presentation at the July 1995 NARUC Meeting,
San Francisco, CA

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Telecommunications Industries Analysis Project:

Schools in Cyberspace: The Cost of Providing Broadband Services to Public Schools

Carol Weinhaus, Teresa Pitts, Linda Garbanati, *et al*.
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The Telecommunications Industries Analysis Project is associated with the Public Utility Research Center at the University of Florida College of Business Administration.

For information on this research, contact Carol Weinhaus at:
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Project Information

List of Participants in the Telecommunications Industries Analysis Project

June 27, 1995

State Regulators	NARUC representatives from: Illinois Commerce Commission Iowa Utilities Board Massachusetts Department of Public Utilities New York Public Service Commission Washington Utilities and Transportation Commission
Regional Holding Companies	Ameritech Bell Atlantic BellSouth NYNEX Pacific Telesis SBC Communications Inc. US WEST
Independents	Anchorage Telephone Utility GTE Sprint Local Telecom Division
Interexchange Carriers	AT&T Sprint
Foreign Domestics	InfoCom Research, Inc. NTT America
Local, National, and International Services	BT France Telecom North America
Materials Manufacturers	Corning
Telecommunications Equipment Manufacturers	Nortel

Sponsors:

Corporation for Public Broadcasting

Assisting with *public* data:

Bellcore
Federal Communications Commission
National Exchange Carrier Association

Project Information, cont.

Background on the Telecommunications Industries Analysis Project

The goal of the Telecommunications Industries Analysis Project is to provide information to support the development of alternative communications policies to meet the needs of stakeholders in an environment that includes competitive and non-competitive markets, federal and state regulatory jurisdictions, and a proliferation of new services made possible by technological advances. The purpose of the project is to produce research and analysis which will assist policy makers in making informed decisions.

The project is a neutral forum of communications industry stakeholders exploring multiple viewpoints of selected issues. This forum incorporates the following elements:

- **Broad representation:** The current forum includes foreign and domestic local exchange carriers (LECs), interexchange carriers (IXCs), materials and equipment manufacturers, and federal and state regulators. The project actively seeks expansion of this forum to include other communications industry representatives such as competitive access providers, cable television companies, computer companies, electric power utilities, or publishers.

- **Multiple viewpoints:** Participants are required to play an active role in the research and analysis, to represent their own interests, to understand and to assist in developing others' perspectives, and to work toward the common goal of representing multiple views.

- **Analysis and results of alternative policies:** Research tools, including a jointly produced data base and computer software models, and data analysis developed by this forum create a common language for examining issues. The common language allows the participants to focus on underlying issues. Appropriate computer software tools, including modifications to existing tools, are developed.

- **All data, analysis methods, and results are public:** Data used by this project must be publicly available on a nationwide basis. Research products become public domain information.

- **Neutral setting**: The project resides in a neutral setting, free of partiality, thereby ensuring objective and independent research.

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List of Acronyms

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FCC	Federal Communications Commission
LAN	Local Area Network
LEC	Local Exchange Carrier
Mbps	Megabits per Second
NII	National Information Infrastructure
PBX	Private Branch Exchange
PC	Personal Computer
PSN	Public Switched Network
U.S.	United States

I. Introduction

Introduction

Currently, there are debates over the provision of advanced telecommunications services (i.e., data transfer, access to the Internet, and access to state networks and libraries) to students and teachers in primary and secondary (kindergarten through twelfth grade) public schools.[1] The FCC, the Administration, Congress, state governments, and local municipalities have all expressed interest in finding ways to provide the education community with access to new technologies and to the interconnected web of public and private networks.

Deploying broadband services is one way to give schools access to new technologies and networks. One issue associated with this deployment is cost: is the cost significant and are broadband services worth the investment?

This paper demonstrates that the additional local exchange carrier (LEC) network investment for providing schools with broadband services is very low compared to school investment and equipment costs. This is also true for providing wideband services.[2] This paper also shows that most of the cost of providing new technologies is driven by two factors:

- Deploying technologies too fast.
- Providing schools with computing equipment, wiring, and training.

The objective of this paper is to present policy makers with information on the cost of providing public schools with broadband access to the Public Switched Network (PSN)[3] via the LECs. The results in this paper supplement existing studies. Specifically, this paper provides costs for one type of broadband technology[4] and gives ranges of costs for capabilities derived from access to broadband services for educational purposes. Although this paper assumes that the broadband infrastructure is provided by LECs, in practice educators may choose other network suppliers.

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[1] In 1993 over 12 percent of school age children were educated in private schools. The costs described in this paper, therefore, do not bring technology to every school child. U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics, Digest of Education Statistics, 1994, U.S. Government Printing Office, Washington, DC, October 1994, page 12, Table 3.

[2] Russell Rothstein and Lee McKnight, "Connecting K-12 Schools to the NII: A Preliminary Assessment of Technology Models and Their Associated Costs," U.S. Department of Education Working Paper, August 4, 1994. Rothstein and McKnight, "Technology and Cost Models of K-12 Schools on the National Information Infrastructure," Massachusetts Institute of Technology, Cambridge, MA, February 10, 1995.

[3] The traditional Public Switched Network is a single nationwide network connecting each telephone on the network to every other telephone on the network. (Definition adapted from AT&T Bell Laboratories, Engineering and Operations in the Bell System: Second Edition, Reorganized and Rewritten Telecommunications in the Bell System in 1982-1983, R.F. Rey (Technical Editor), Murray Hill, NJ, 1983, page 3.) For purposes of this paper, the PSN will include both the traditional telephone networks and emerging broadband networks, such as video networks and the Internet.

[4] Technology that supports data rates of 45 Mbps (Megabits per second) or greater is called broadband. The broadband platform can support both MPEG-II and 45Mbps or greater.

I. Introduction, cont.

The rest of this paper covers the following items:

- **Section II, Broadband Model Results:** Presents results for two broadband deployment schedules. In one, schools receive broadband technologies as part of a20-year nationwide deployment. In the other, broadband network deployment follows a 5-year accelerated schedule for the schools. Three scenarios for classroom costs, including the costs of computers and other equipment, are modeled for both deployment schedules.

- **Section III, Wideband and Broadband Deployment Definitions and Assumptions:** Provides definitions and assumptions for wideband and broadband deployments. The broadband data in this paper supplements previous research on the deployment of wideband technologies to public schools.

- **Section IV, Public Debate over Expenditures for Schools:** Discusses different policy views associated with expenditures for education. While it is necessary to understand the costs underlying the various choices for providing communications services to the schools, it is important to view these decisions within the larger context of the debate over expenditures for education in general.

- **Section V, Appendix A, LEC and School Cost Charts:** Contains additional charts for LEC network investment and school costs. Allows comparisons among deployment schedules and scenarios.

- **Section VI, Appendix B, Incremental Investment per Student per Year Charts:** Contains additional charts for comparisons of the incremental investment per year. Allows comparisons among deployment schedules and scenarios.

- **Section VII, Appendix C, Background Data:** Provides background data for the charts.

Wideband Deployment Assumptions and Costs

This paper provides data on the costs to provide classrooms with access to the PSN via broadband technology.[5] These broadband results supplement previous wideband research results published by the Department of Education, and by Rothstein and McKnight, hereinafter referred to as the *Wideband Papers*.[6] The term "wideband" refers to the focus of those papers on access technology capable of providing data rates and services up to 1.544 Mbps. This paper expands the range of services that might be considered for public schools by provision of fiber-optic broadband access,[7] and gives new total system costs for both LEC network infrastructure and school premises equipment. To get a sense of the difference between the wideband and broadband transmission rates, the contents of Tolstoy's War and Peace can be sent in twenty-six seconds with wideband (1.544 Mbps) and in one second with broadband (greater than 45 Mbps).[8] See **Section III** for a description of the definitions and assumptions for this wideband deployment.

The *Wideband Papers* estimate total system costs using these items for five different service configurations involving local schools, a district office, and levels of service to the local schools. The configurations progress from a model consisting of the most basic service level, with a line and modem connecting a school to its district office, up to a model consisting of full, ubiquitous wideband connection for the local school to the telecommunications network (hereinafter referred to as the "wideband model").

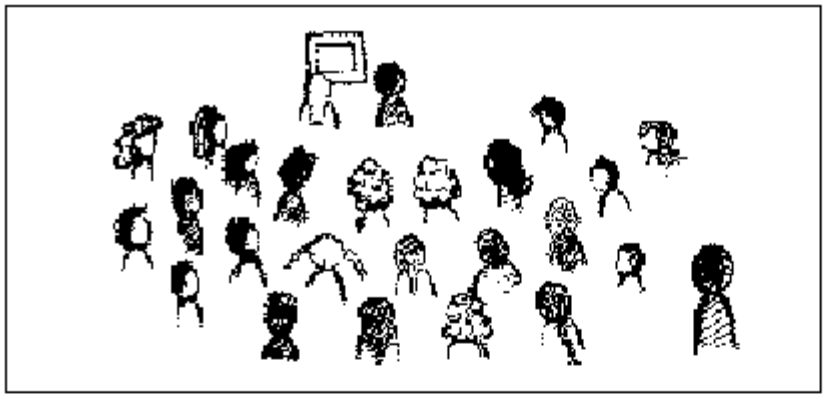
The estimated costs for nationwide deployment of this wideband model are $51 billion in startup costs, with $4 billion in annual operating expenses. [9]

Broadband Model Results

Two deployment schedules for public schools are compared - a 20-year nationwide broadband deployment and a 5-year broadband accelerated deployment. Three access-to-technology scenarios are modeled for each of the two schedules. These scenarios **(Figure 1)** are *teacher only* (only one computer per classroom), *team of students* (seven computers per

[5] For further information regarding broadband technology see Carol Weinhaus, Linda Garbanati, *et al., Overview of New Technology Deployment Model: Broadband with Associated Depreciation and Overheads,* Telecommunications Industries Analysis Project, Public Utility Research Center, College of Business Administration, University of Florida, March 15, 1995. See also the *1995 User Guide* associated with the model.
[6] See Rothstein and McKnight, *Connecting K-12 Schools* and *Technology and Cost Models of K-12 Schools.*
[7] Greater than 1.544 Mbps
[8] Assumes a 2400 baud modem
[9] Costs for the other configurations range from $.07 billion in startup costs with $.15 billion in annual operating expenses for the most basic configuration up to the high estimate of the wideband model of $113.5 billion in startup costs and $10 billion in annual operating expense. For more information, see *Wideband Papers*..

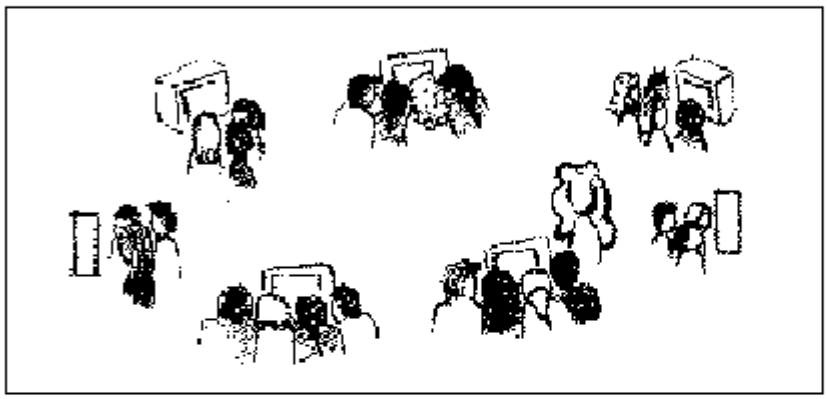
Figure 1: Three Scenarios for Broadband Deployment to Public Schools: Kindergarten through Twelfth Grade



Teacher-Only Access:

1 PC

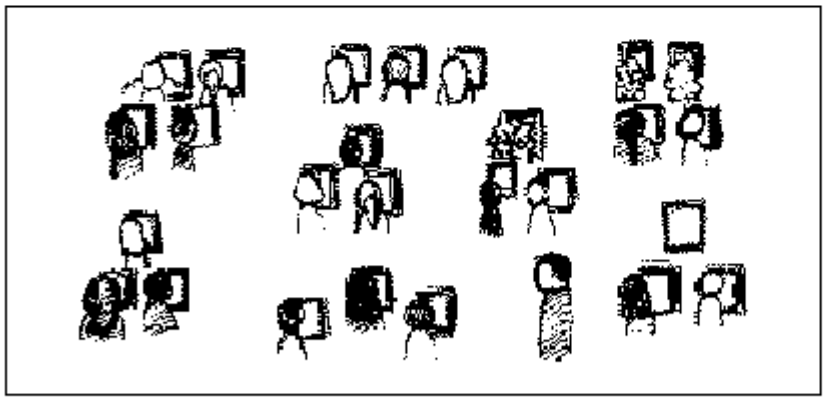
Scenario 1



Team-of-Students Access:

7 PCs

Scenario 2



Universal Access:

26 PCs

Scenario 3

Common Assumptions (per School):
- 2 Video Instructional Areas

Common Assumptions (per Classroom):
- 1 Teacher and a Class of 25 Students
- 1 Telephone
- 1 Scanner
- 1 Printer

classroom),[10] and universal (every student and teacher has a computer). For descriptions of these schedules and scenarios, see **Section III**.

For a description of the schedules and the three scenarios see **Section III**. The results indicate the following points:

- The range of total costs for the 20-year broadband deployment is $14.7 billion for the teacher-only access scenario to $118.3 billion for the universal access scenario. The range for the 5-year accelerated deployment[11] for these two scenarios is $28.6 billion to $204.4 billion **(Figure 2)**.

- If broadband deployment to public schools is accelerated to five years instead of integrated as part of a 20-year nationwide deployment, LEC network investment costs are approximately five times as much (**Figure 3)**. Acceleration of deployment to the schools produces significantly higher costs. This is due to the fact that more equipment is purchased in the early stages when prices are higher and to the fact that there will be little sharing of common facilities and civil works with other customers.

- The pattern in **Figure 2** LEC investment indicates the 5-year accelerated schedule provides less opportunity for sharing installation costs among all customers and requires buying sophisticated equipment at a premium price early in the equipment's market life when prices for net technology tend to be higher. The 20-year schedule shows the cost advantages associated with a staged roll out of all equipment. In the 20-year schedule, costs for network investment are shared over all available services and investment is stimulated by wider market demand and an integrated cost-effective modernization of facilities.

- LEC network investment costs are dwarfed by the school costs, especially as the number of computers per classroom approaches the number of students per classroom. In the case of universal deployment of computers (a computer on every desktop), even the expense associated with software upgrades and Internet access charges rapidly exceeds the LEC network investment costs. LEC network investment costs are $2.2 billion for the 20-year deployment **(Figure 4)** and $10.2 billion for the 5-year accelerated deployment **(Figure 5)**. Depending on the scenario, these costs range from 1.9% to 35.6% of total costs. [12]

  This pattern of relatively high investment by schools and low investment by LECs is especially evident in the most extensive scenario (universal access, **Figures 4 and 5**).

[10] Assume in each classroom the teacher has a PC and twenty-five percent of the students have a PC

[11] Extended to include costs over twenty years.

[12] For data for individual years, see **Section VII, Appendix C, Figures 24 through 29.**

Figure 2: LEC Investment and School Costs by Category: Broadband Deployment to Public Schools, 5-Year Accelerated and 20-Year

Investment Category	Scenario 1: Teacher-Only-Access		Scenario 2: Team-of-Students Access		Scenario 3: Universal Access	
	Dollars (in Billions)	Percent	Dollars (in Billions)	Percent	Dollars (in Billions)	Percent
5-Year Accelerated Broadband Deployment						
School Annual Software Expense and Internet access	$2.7	9.3%	$18.7	26.9%	$69.5	34.0%
School Investment (including replacements)	$15.7	55.1%	$40.7	58.5%	$124.7	61.0%
Network Investment	$10.2	35.6%	$10.2	14.6%	$10.2	5.0%
Total	$28.6	100.0%	$69.6	100.0%	$204.4	100.0%
20-Year Broadband Deployment:						
School Annual Software Expense and Internet Access	$1.4	9.2%	$9.5	24.7%	$35.2	29.8%
School Investment (including Replacements)	$11.1	75.9%	26.7$	69.6%	$80.9	68.4%
Network Investment	$2.2	14.9%	$2.2	5.7%	$2.2	1.9%
Total	$14.7	100.0%	$38.3	100.0%	$118.3	100.0%

Figure 3: **Comaparison of Total LEC Investment Costs: Broadband Deployment to Public Schools, 5-Year Accelerated and 20-Year**

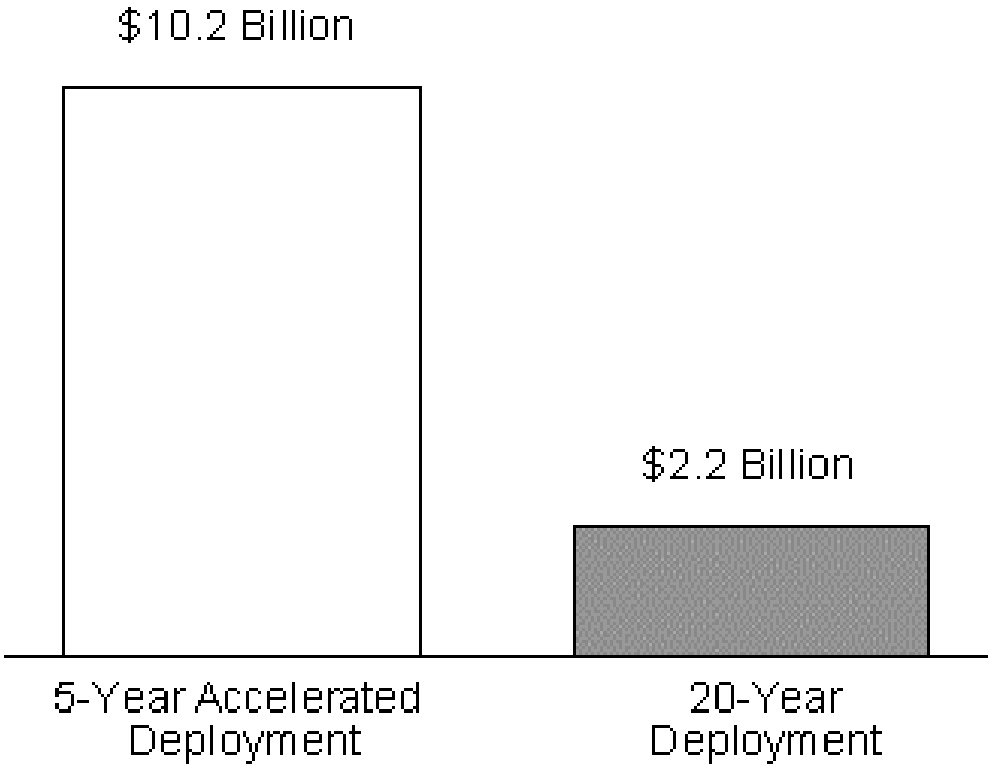
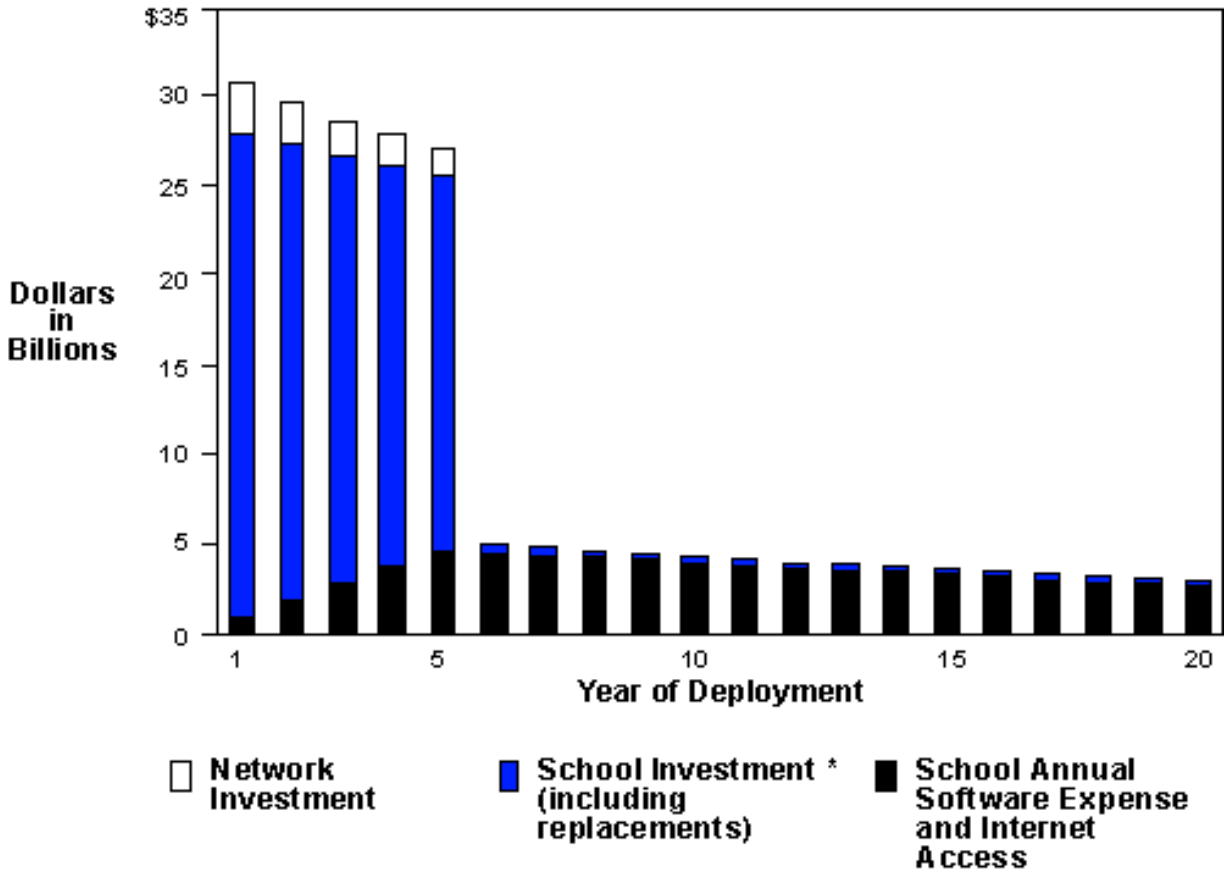
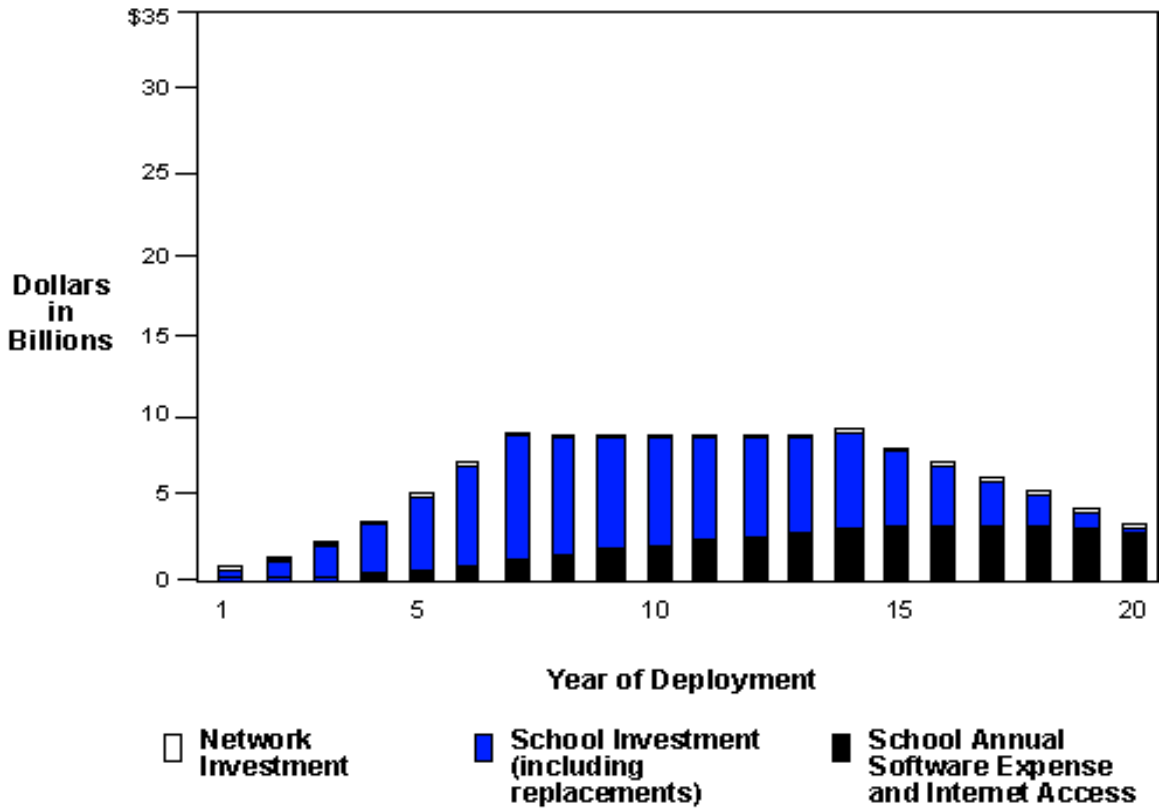


Figure 4: **Comparison of School Costs with LEC Network Costs:**
5-Year Accelerated Broadband Deployment, Universal Access (Scenario 3)



* In the 5-year accelerated deployment, replacement costs for school investment in computers, etc., is minimal in relationship to the initial investment and, therefore, is not immediately visible in years 6 though 20. Modeling the costs out to 20 year allows comparisons with the 20-year deployment.

Figure 5: Comparison of School Costs with LEC Network Costs:
20-Year Broadband Deployment, Universal Access (Scenario 3)



* In the 5-year accelerated deployment, replacement costs for school investment in computers, etc., is minimal in realtionship to the initial investment and, therefore, is not immediately visible in years 6 though 20. Modeling the costs out to 20 years allows comparisons with the 20-year deployment.

While not as extreme, this same pattern also holds true for the simplest scenario (teacher-only access) which provides only one PC per classroom. [13]

- LEC network investment costs are indifferent to the number of PCs per classroom **(Figures 4 and 5)**. Data rates supported by broadband equipment and fiber-optic cable are so great that these costs are insensitive to the variation in the demand for data services due to the number of PCs.

- The incremental investment per student per year **(Figures 6 and 7)** indicates that the universal access scenario costs approximately twice as much as the team-of-students access scenario and approximately seven times as much as the teacher-only access scenario. Incremental investments remain relatively constant over time for these two less extensive deployments. [14]

- In terms of the incremental investment per student per year, the decision to accelerate broadband deployment beyond the nationwide deployment produces an effect that isn't erased with time. This difference is most evident in the comparison of 5-year and 20-year deployments of the universal access scenario **(Figure 8).** By the sixth year, the investments diverge dramatically. To a lesser degree, this same pattern appears in the teacher-only access and in the team-of-students access scenarios. [15]

- In 1992 public school expenditures per student were approximately $5,200. A comparison of this number with the results from the model in **Figures 6 and 7**, indicate potential for increased expenditures. However, as noted before, it is difficult to determine the impact of new technology on existing expenditures. For the universal access scenario, incremental investments per student may double current expenditures, while for the teacher-only access scenario, investments may increase by ten percent.[16]

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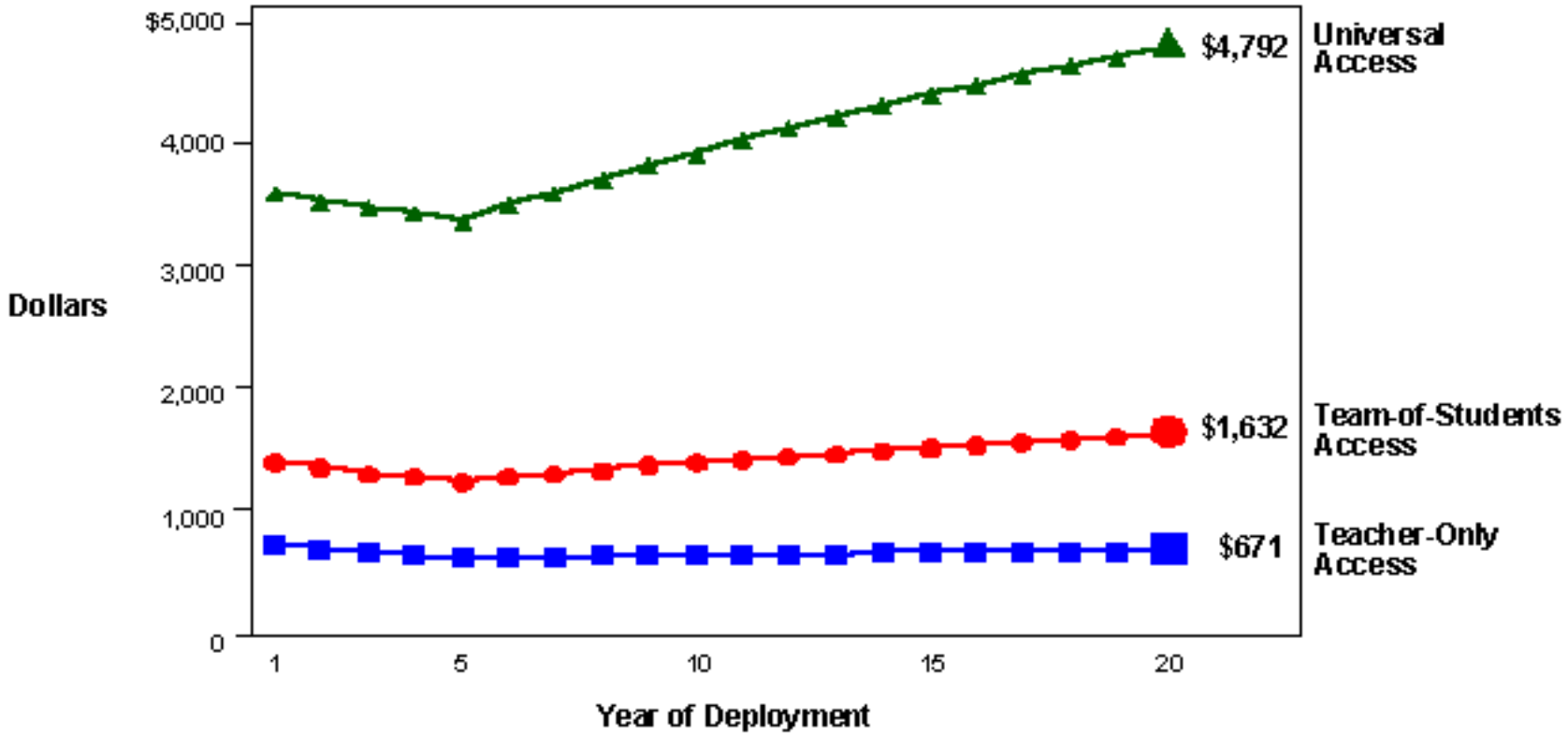
[13] See **Section v, Appendix A,** for similar comparisons for Teacher-Only Access (Scenario 1, **Figures 13 and 14**), and for Team-of-Students Access (Scenario 2, **Figures 15 and 16**). **Appendix A** also contains additional charts with the y-axis scaled to indicate the patterns occurring among each scenario's categories **(Figures 17 through 21).** The scenario for **Figure 4** is not included in this set because in this case the y-axis is already scaled to the data set.

[14] For background numbers, see **Section VII, Appendix C, Figure 30.**

[15] See **Section VI, Appendix B**, for similar comparisons for Teacher-Only Access (Scenario 1, **Figures 22)**, and for Team-of-Students Access (Scenario 2, **Figure 23**), For background numbers, see **Figure 30.**

[16] The 1992 projected expenditures were $5,127 per student. This is based on projections of 27,834 thousand public elementary school students, 14,752 thousand public secondary school students, and $221.3 billion in expenditures by public elementary and secondary schools. U.S. Department of Commerce, *Statistical Abstract of the United States*, 1993, 113th Edition, U.S. Government Printing Office, Washington, DC, 1993, page 147, Tables 221-222.

Figure 6: **Incremental Investment per Student per Year for Three Access Scenarios: 5-Year Accelerated Broadband Deployment**



*Modeling the costs out to 20 years allows comparison between the 5-year accelerated and the 20-year deployment schedules.

Figure 7: **Incremental Investment per Student per Year for Three Access Scenarios: 20-Year Broadband Deployment**

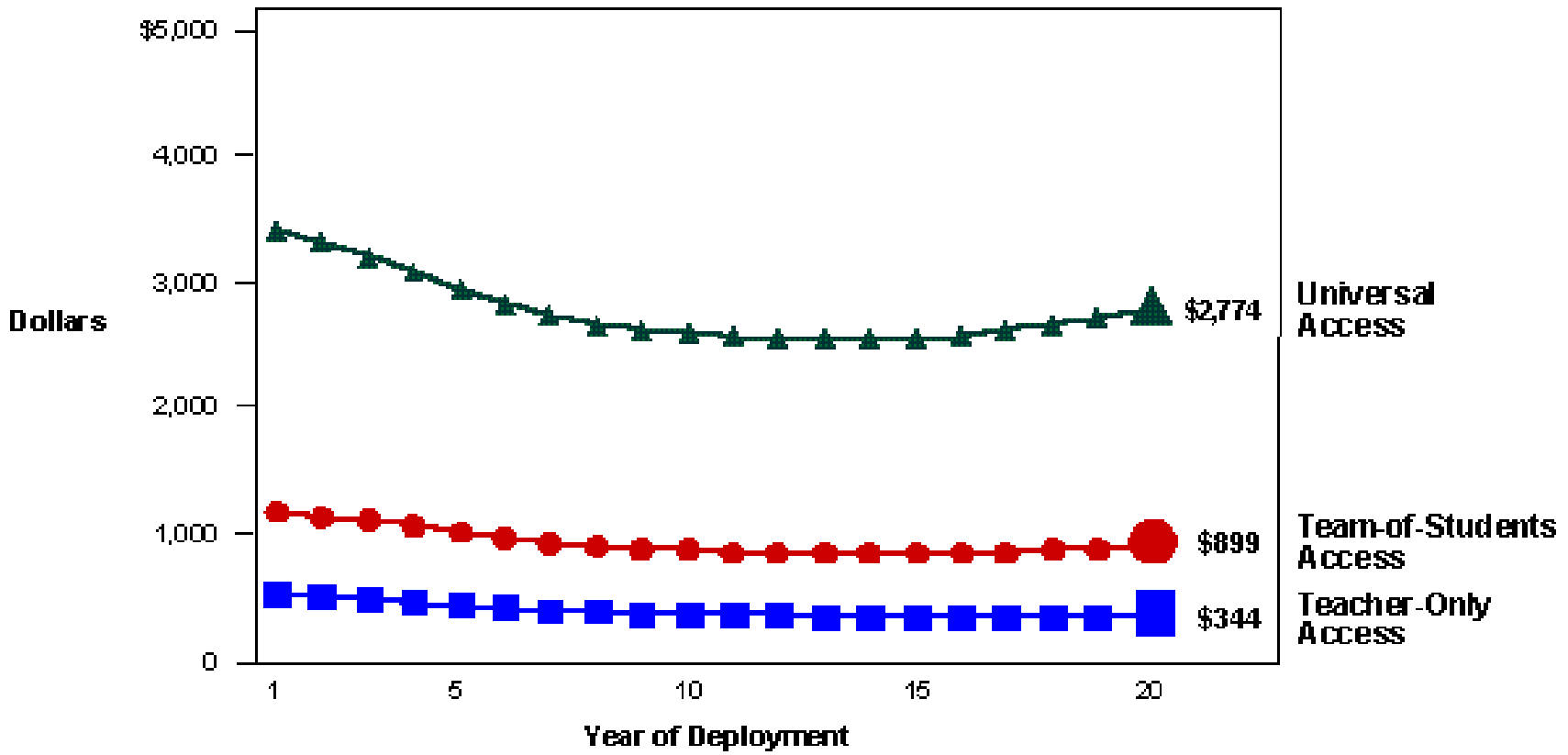
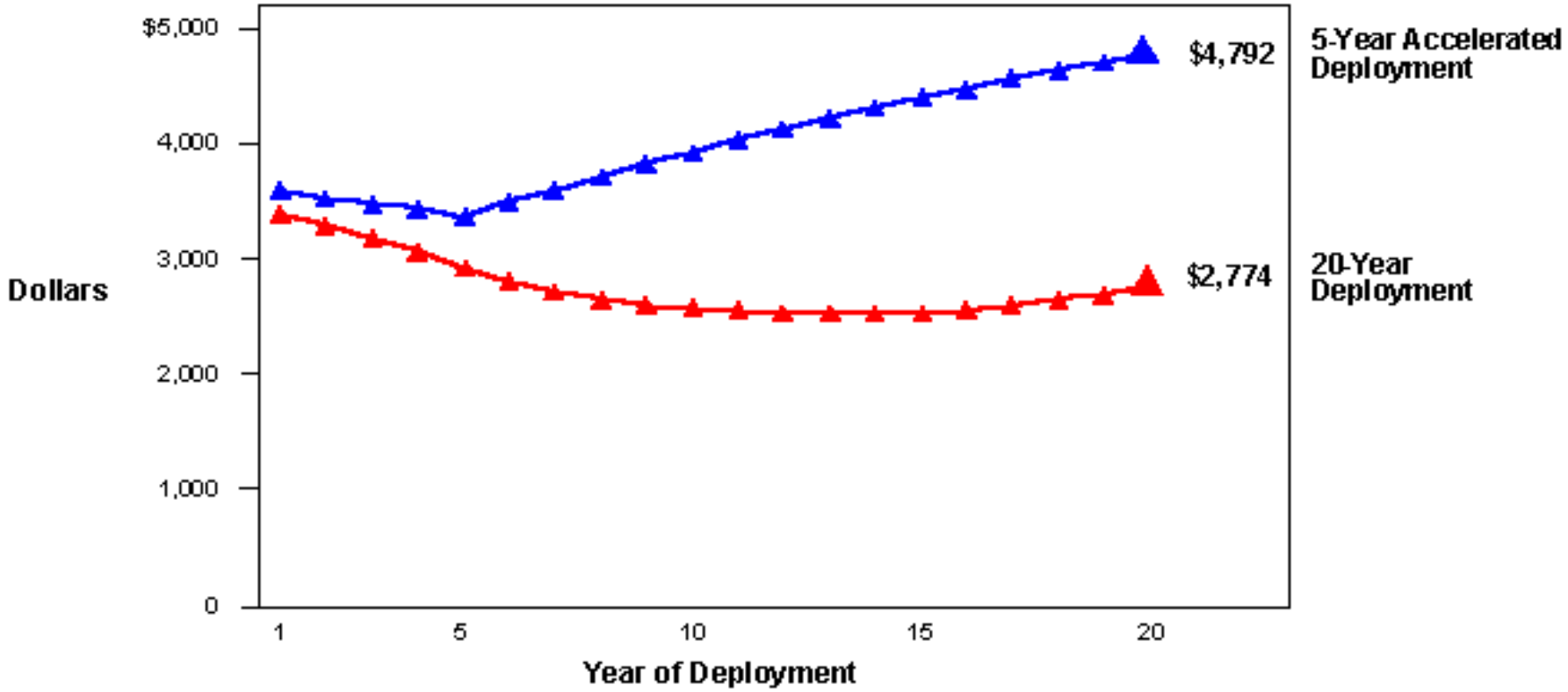


Figure 8: **Incremental Investment per Student per Year for Universal Access (Scenario 3): 5-Year Accelerated and 20-Year Broadband Deployment**



*Modeling the costs out to 20 years allows comparison between the 5-year accelerated and the 20-year deployment schedules.

III. Wideband and Broadband Dployment Definitions and Assumptions

Wideband Deployment Assumptions and Costs

Figures 9 and 10 illustrate the wideband network used in the **Wideband Papers**. In the *Wideband Papers*, the authors included estimates for the following cost components:

- Average tariffed rates for selected services,
- Customer (school) provided equipment,
- Re-wiring the school and installing equipment,
- Retrofitting the schools, [17]
- Teacher and staff training, and
- Technical support.

The most extensive deployment model in the **Wideband Papers** defines total system costs for a full, ubiquitous wideband connection for local schools and district offices to the telecommunications network and includes the following:

- A personal computer (PC) on every desk,
- A Local Area Network (LAN) with file servers and routers in each school, and
- Wideband interconnections to other schools in the district and to the network.

Broadband Deployment Definitions and Assumptions

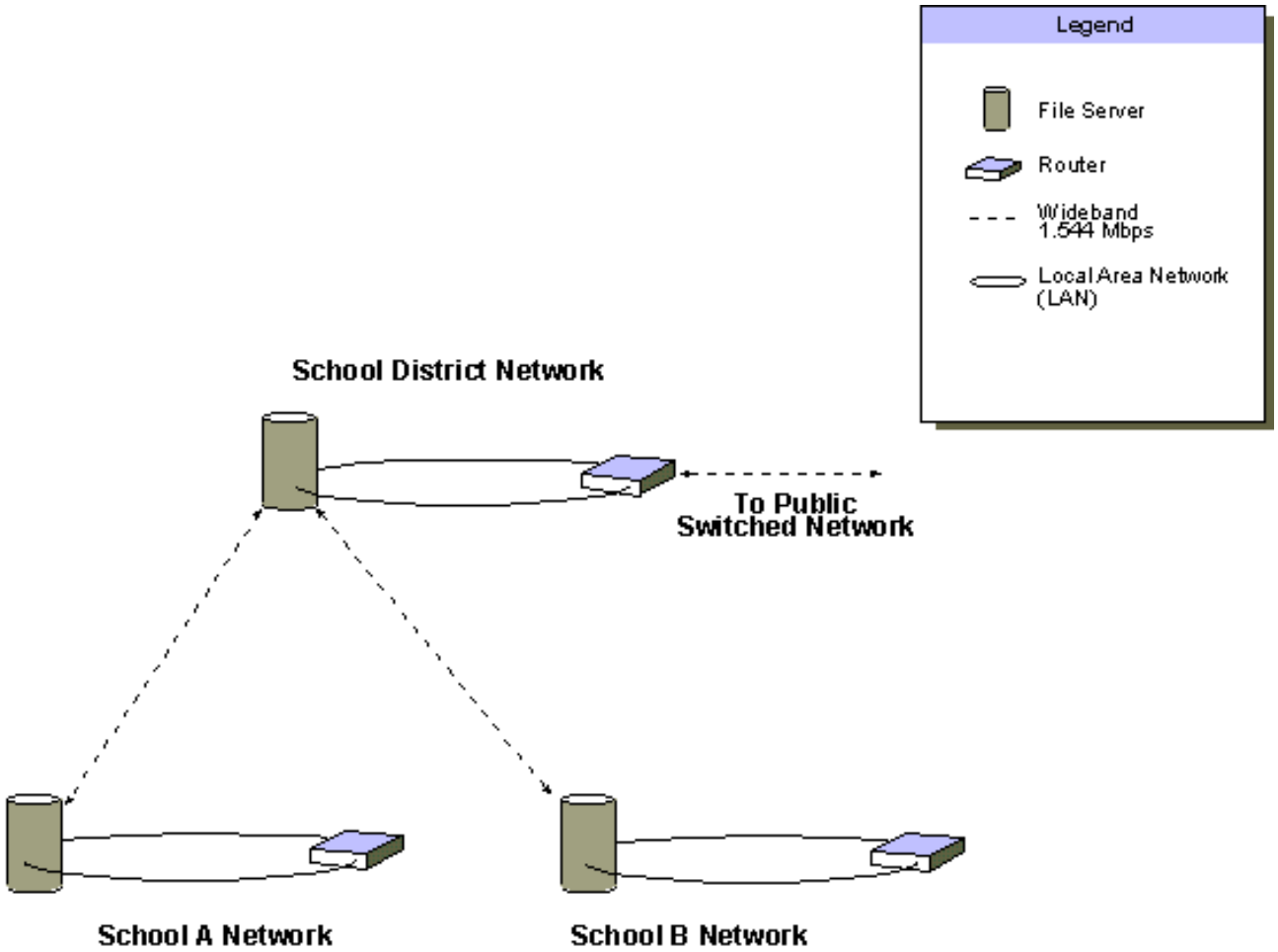
This paper provides the costs for connecting the schools to the network using two deployment schedules - five years and twenty years for broadband access and school equipment. Both schedules assume a nationwide, ubiquitous deployment of a broadband infrastructure in the LEC telecommunications networks over a twenty year period. To provide valid comparisons between the two deployment schedules, the modeling cost results are based on comparisons of twenty year periods for three access-to-technology scenarios (teacher-only, team-of-students, and universal). However, the differences between the two schedules are as follows:

- **20-Year Schedule**: Assumes all schools will have broadband access and equipment by the end of the twenty years. It assumes that the deployment pattern in the schools matches the nationwide deployment pattern so that the schools receive access to the new technologies at the same rate as the rest of the nation.

- **5-Year Accelerated Schedule**: Assumes the schools will have broadband access and equipment within five years and that the deployment will be uniform

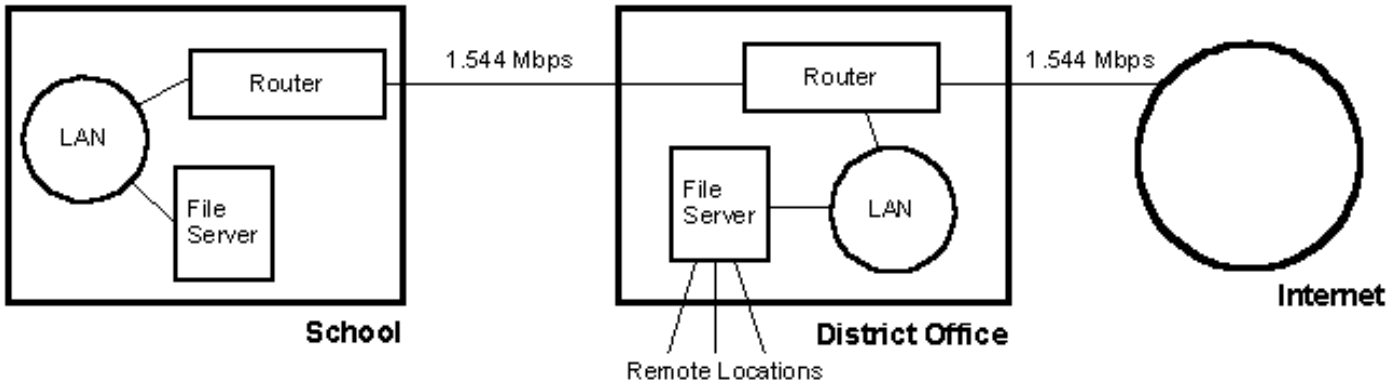
[17] Customer (school) provided equipment includes routers, servers, and PCs. The retrofitting costs include asbestos removal required to install new telephone and electrical wires, new environmental systems to protect the hardware, and upgrading the electrical systems to support both new hardware and environmental systems.

Figure 9: Wideband Deployment Architecture*



* Adapted from R. Rothstein and L. McKnight, "Technology and Cost Models of K-12 Schools on the National Information Infrastructure," pages 19-20.

Figure 10: Simplified Block Diagram for Wideband Deployment*



*Adapted from R. Rothstein and L. McKnight, "Technology and Cost Models of K-12 Schools on the National Information Infrastructure," Figure 7, p. 19.

throughout the five-year period. In this case, the schools receive new access technologies long ahead of the entire nation. This deployment requires a special design and does not match the national deployment. The 5-year schedule is an accelerated network deployment.

In order to make comparisons between the two schedules, additional school investment and expenditures (i.e., periodic equipment replacement and software upgrades) for years 6 through 20 are included in the 5-year schedule results. Both deployment schedules also assume the following:

- Broadband is defined as technology that supports multiplexed data rates in excess of 45 Mbps.
- Only costs for kindergarten through 12th grade **public** schools will be considered.
- School numbers include equipment and software costs for upgrades every five years.
- All data concerning school size, classroom size, number of students, number of school districts, etc., are from public sources. [18] The basic statistics are as follows:

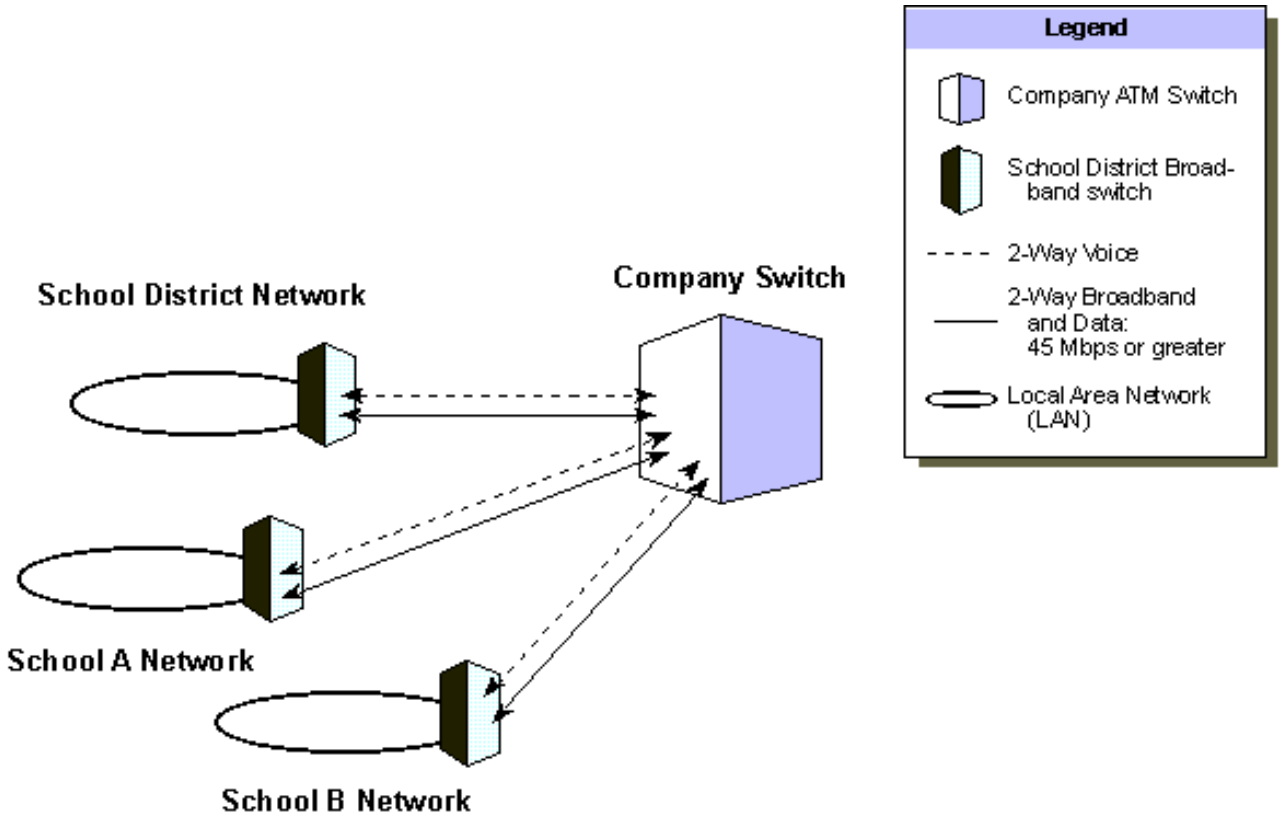
15,025	public school districts,
84,501	schools,
42,586,000	public elementary and secondary school students, and
25	students per classroom.

- The broadband service platform (illustrated in **Figures 11 and 12**) provides enough bandwidth for data transfer, faxing, voice communications, and two way video services. [19]

[18] Number of public school districts: *Digest of Education Statistics, 1994,* page 96, Table 89 (1992-1993 data). Number of schools: *Digest of Education Statistics, 1994,*page 96, Table 89 (1992-1993 data). Number of students: *Statistical Abstract of the U.S. 1993,* page 158, Table 239 (1992 projection). Average number of students per classroom: *Digest of Education Statistics, 1994,* page 79, Table 69 (1991 data)

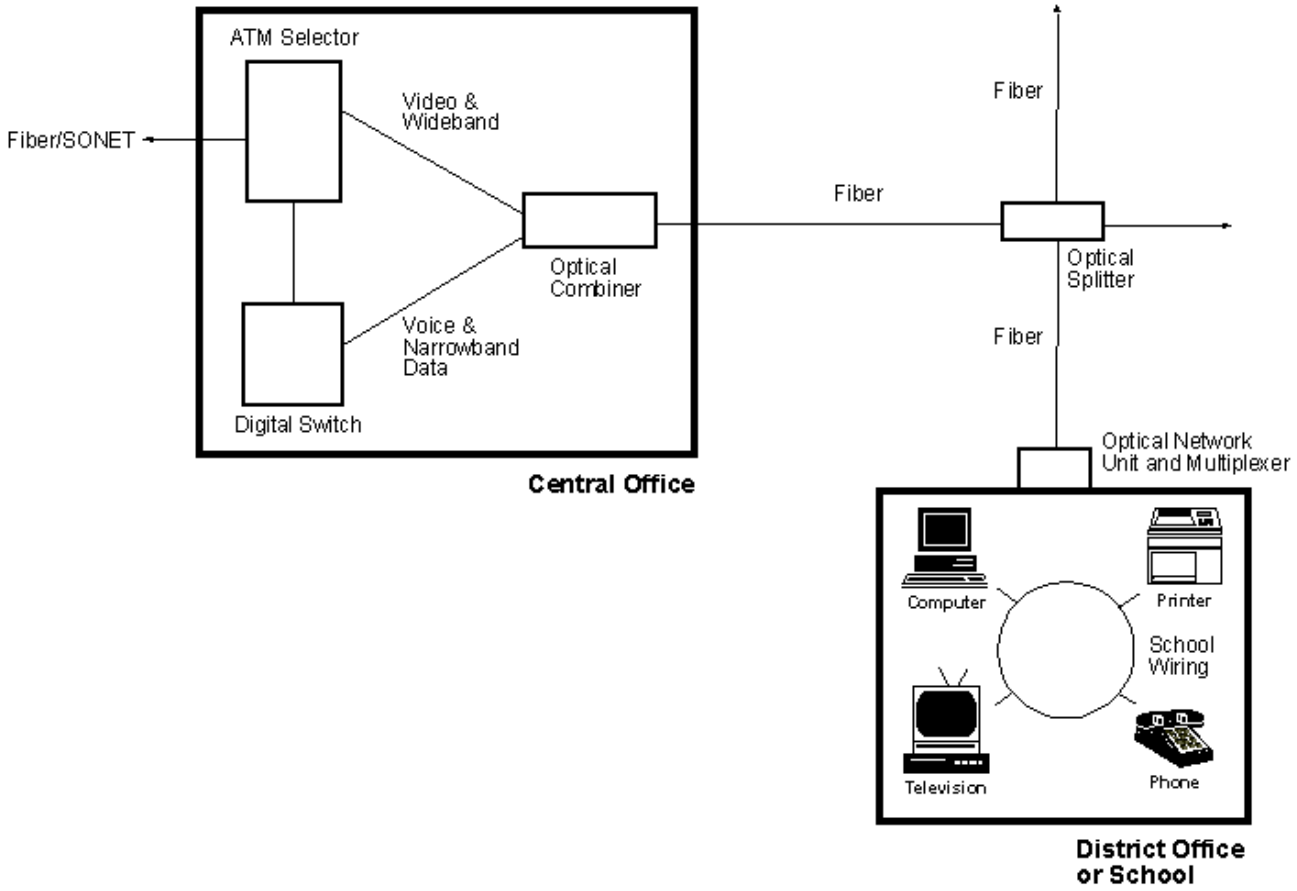
[19] The broadband deployment used in this paper is based on the residential deployment for broadband developed in the *New Technology Deployment Model* and described in the *Overview of the New Technology Deployment Model* and the *1995 User Guide*.

Figure 11: **Broadband Deployment Architecture**



For definitions of broadband technology architecture and assumptions, see Carol Weinhaus, Linda Garbanati, *et al., Overview of New Technology Deployment Model: Broadband with Associated Depreciation and Overheads,* Telecommunications Industries Analysis Project, Public Utility Research Center, College of Business Administration , University of Florida, March 15, 1995. See also the *1995 User Guide* associated with the model.

Figure 12: Simplified Block Diagram for Broadband Deployment



For definitions of broadband technology, architecture and assumptions, see Carol Weinhaus, Linda Garbanati, *et al., Overview of New Technology Deployment Model: Broadband with Associated Depreciation and Overheads,* Telecommunications Industries Analysis Project, Public Utility Research Center, College of Business Administration, University of Florida, March 15, 1995. See also the *1995 User Guide* associated with the model

- Variations in costs are driven by the amount of equipment (PCs, telephones, etc.) assumed to be present in each classroom. Figure 1 illustrates the three scenarios modeled in this paper:

	Number of Personal Computers (PCs) per Classroom	
	1 Teacher	25 Students
Scenario 1: Teacher-Only Access	1 PC	None
Scenario 2: Team-of-Students Access	1 PC	6 PCs
Scenario 3: Universal Access	1 PC	25 PCs

Common to all scenarios are the following service assumptions: two video instructional areas per school and 1 telephone, 1 scanner and 1 printer per classroom.

- Incremental investment per student per year is calculated by dividing the sum of costs calculated for that year and for all prior years by the total number of students that have been provided broadband network access and desktop equipment.

- Incremental investments per student are only modeled for the deployment of broadband technology. The impact on existing education costs is not included in this paper. Since it is hard to determine how technology might be used, it is difficult (if not impossible) to determine how investment in technology might replace other costs and to what extent.

- All costs are expressed in current dollars.

- The cost includes an annual expense for Internet access and usage based on current rates and projections.[20]

Definition of Costs for Broadband Deployment

The costs are defined as costs incurred by LECs to upgrade their networks to provide broadband services to the school and as costs for customer provided equipment that would be required by the schools. The results divide total costs into the following three categories:

[20] Personal communication, McKinsey and Co., Inc., June 1, 1995.

- **Network Investment:** Includes all LEC investment costs.

- **School Investment:** Includes costs for PCs and other equipment such as telephones, televisions, video equipment, scanners, printers, PBXs,[21] and file servers, as well as training [22], school retrofitting for appropriate asbestos removal and air-conditioning and electrical upgrades, LAN interconnection and other wiring, and periodic equipment replacements.

- **Annual School Software Expense and Internet Access Costs:** Includes operational and educational software, Internet fees, and upgrading annual software expenses.

This paper focuses on installation costs incurred by schools and by LECs. This paper does not address how these costs should be recovered. Therefore, tariffed rates for telephone services or enhanced broadband services are excluded from the broadband scenarios modeled.[23] Ongoing expenses for maintenance and operations are also excluded from all costs.

[21] As part of the deployment of the broadband network, the model assumes that schools will use Private Branch Exchanges (PBXs) - switches that are part of the school's network - to handle the switching associated with their internal networks and for access to the National Information Infrastructure (NII). However, schools may select the network switching solution that best fit their own needs. The choices may be a PBX or a LEC central office switching service, such as Centrex, or other services.

[22] Costs of training existing teachers are included. New teachers are assumed to have been trained during college and costs for this training are therefore excluded. Note that teachers may also train one another.

[23] Network Infrastructure costs are accounted for by tariffed rates in the *Wideband Papers*.

Public Debate over Expenditures for Schools

While this paper provides data for the debates over the deployment of technology to the schools, technology deployment is only one area in a larger debate over public expenditure for schools. There is general agreement that the trend towards global, competitive markets means that U.S. workers will need new skills to continue to play a leading role in the world economy. However, different people have different views on how schools should use and obtain information technologies to prepare students for the future.

One view is that the federal government should play a leading role in getting broadband services to schools. This view suggests that schools are underutilizing information technologies. Few schools in the U.S. have more than one or two telephone lines, even fewer have a telephone per room, and fewer still have modems and communications lines for computers. [24] For example, the National Education Association and Federal Government have found that most schools are not equipped to make full use of computers and only twelve percent of the classrooms have a phone line. [25] The advancements in new technologies coupled with their absence in public schools has led to government initiatives. Two such responses are the FCC's challenge to the communications industries to connect classrooms and libraries to the PSN [26] and the Clinton Administration's National Information Infrastructure (NII) initiative that emphasizes school access to the PSN.

Another view is that heavy involvement by the federal government is counter-productive. This view suggests that parents, teachers, other local school officials, and students have a better grasp of their specific situations. Information technologies may or may not improve students' learning. For example, sometimes a leak in the roof takes precedence over communications needs. Also, they may want to apply new technologies in ways that would not fit a federal framework. This view concludes that flexibility and local initiatives are key in preparing students for world-class competition.

It is possible to mix these two views. In this case the nationwide deployment and individual tailored deployments by communities and/or states are not mutually exclusive. For example, there might be broad federal policies outlined with implementation given to the states.

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[24] Increasing the numbers and availability of telephone lines raises management issues for schools as they try to control students making long distance calls.

[25] "U.S. Schools Found Lagging in Vital Technologies," *The New York Times*, April 5, 1995, page A 21.

[26] *Interactive Age,* "FCC's Hundt Makes Education No. 1," January 30, 1995, page 11.

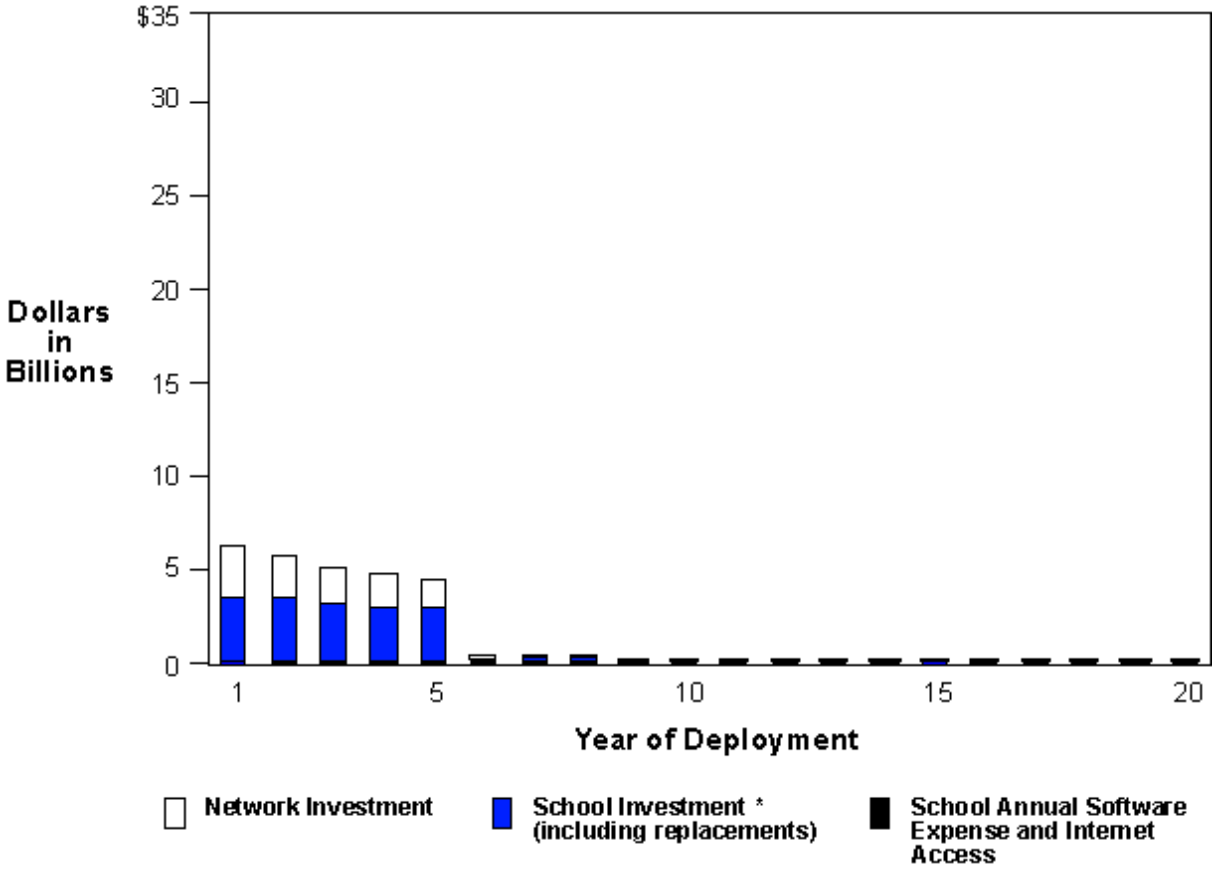
Regardless of whether a person subscribes to one of these views, or yet another view, knowing the cost of technology is important. Educators will be purchasing technology. Therefore, policy makers need to understand the impact of these purchases on school budgets. The following issues are key:

- Who should receive funding? Public schools? Private schools? Home learning programs?
- Who will pay for school expenses? What are the payment structures and mechanisms?
- Who decides where educational funds should be spent?
- What is the role of communications technologies? Who will pay for their deployment? Should any technologies be mandated?

Infrastructure will be necessary to extend the use of computers, both in numbers and in application. This infrastructure would allow the nation's public school classrooms and libraries to access a worldwide information network. However, constructing this infrastructure is only part of the equation. Another critical step is to develop a framework that allows teachers and students to apply electronic communications where it enhances learning.

V. Appendix A: LEC and School Cost Charts

Figure 13: **Comparison of School Costs with LEC Network Costs:**
5-Year Accelerated Broadband Deployment, Teacher-Only-Access (Scenario 1)



*In the 5-year accelerated deployment, replacement costs for school investment in computers, etc., is minimal in relationship to the initial investment and therefore is not immediately visible in years 6 through 20. Also, modeling the costs out to 20 years allows comparisons with the 20-year deployment

Figure 14: **Comparison of School Costs with LEC Network Costs: 20-Year Broadband Deployment, Teacher-Only-Access (Scenario 1)**

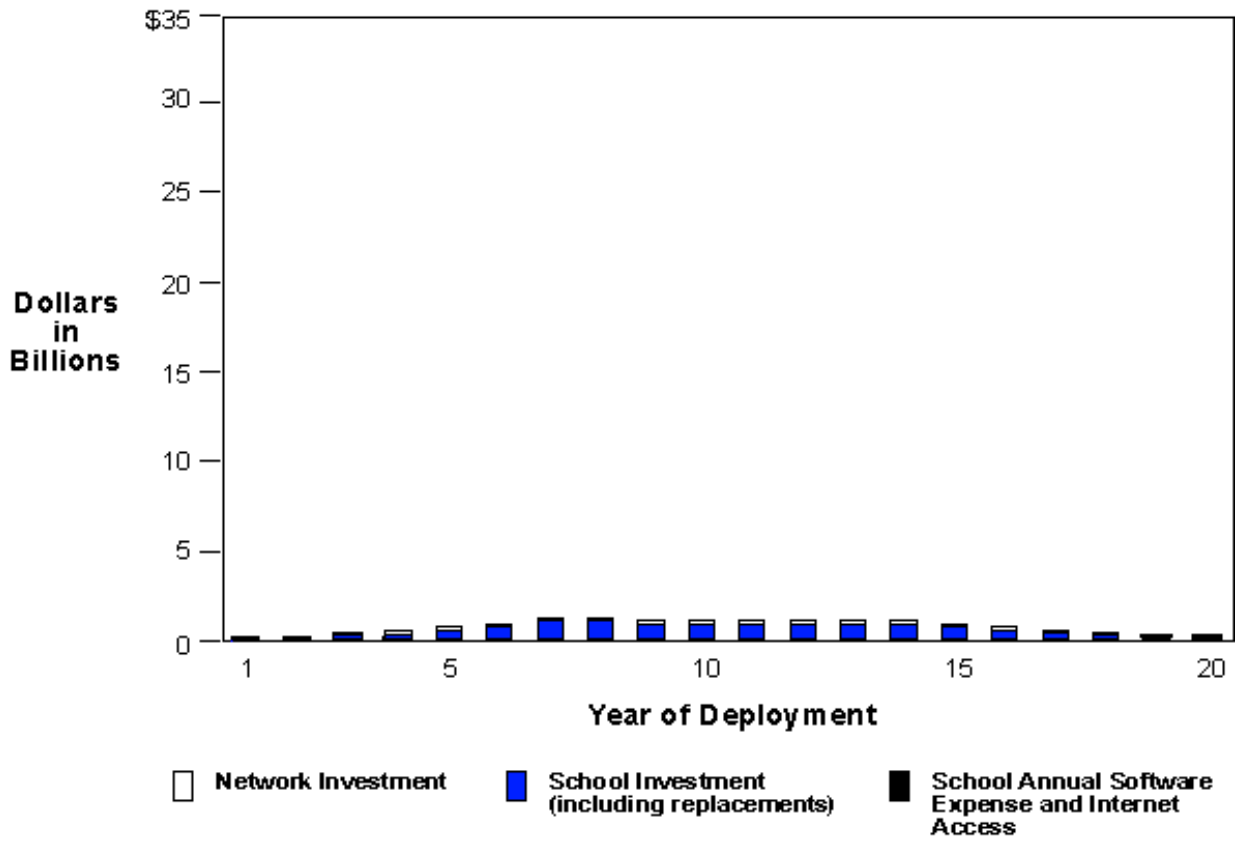
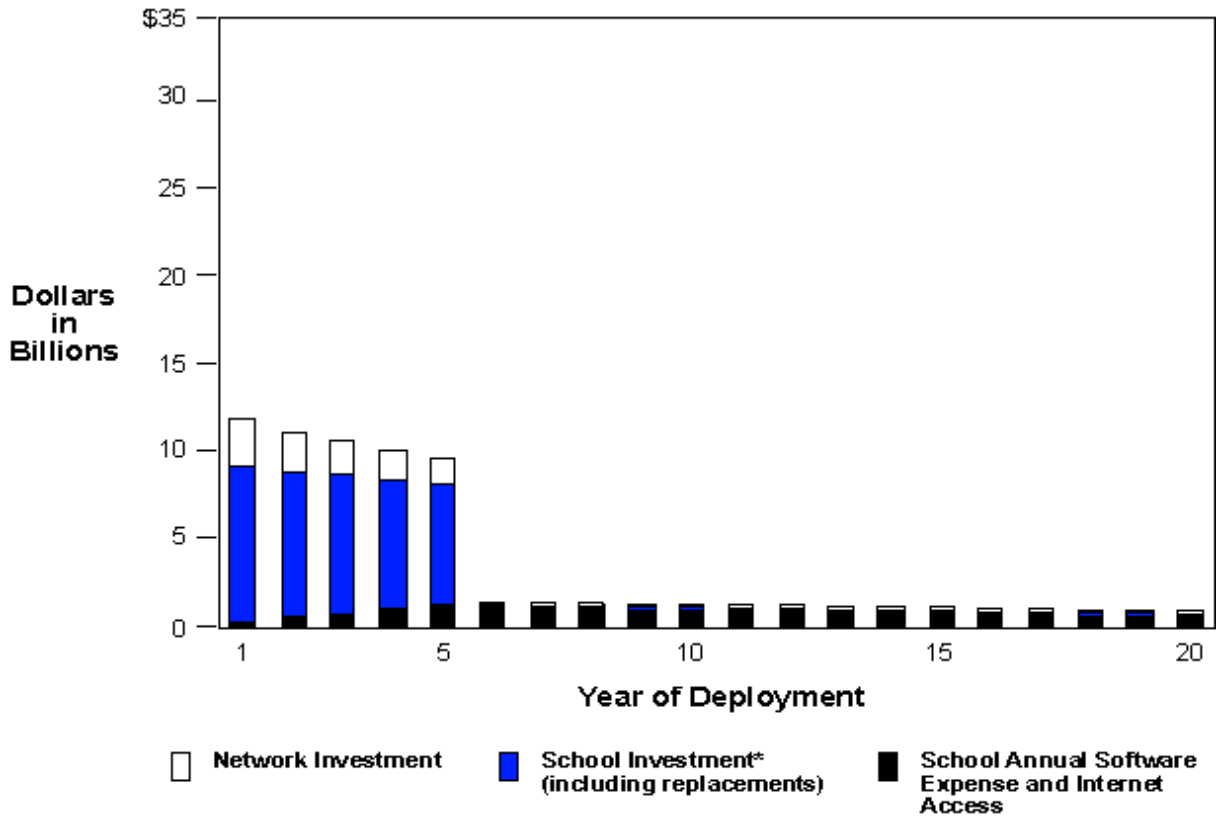


Figure 15: **Comparison of School Costs with LEC Network Costs:**
5-Year Accelerated Broadband Deployment, Team-of-Students Access (Scenario 2)



*In the 5-year accelerated deployment, replacement costs for school investment in computers, etc., is minimal in relationship to the initial investment and therefore is not immediately visible in years 6 through 20. Also, modeling the costs out to 20 years allows comparisons with the 20-year deployment.

Figure 16: **Comparison of School Costs with LEC Network Costs:
20-Year Broadband Deployment, Team-of-Students Access (Scenario 2)**

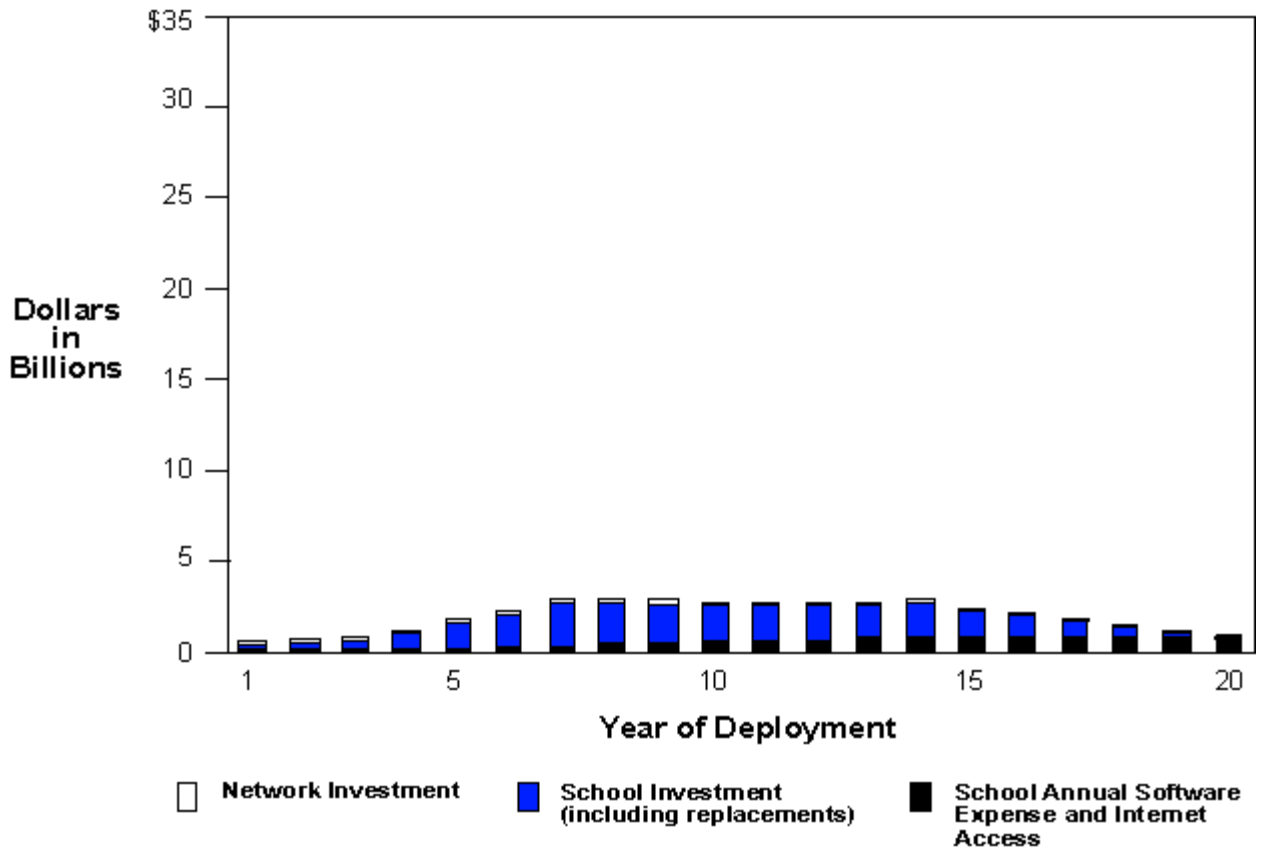
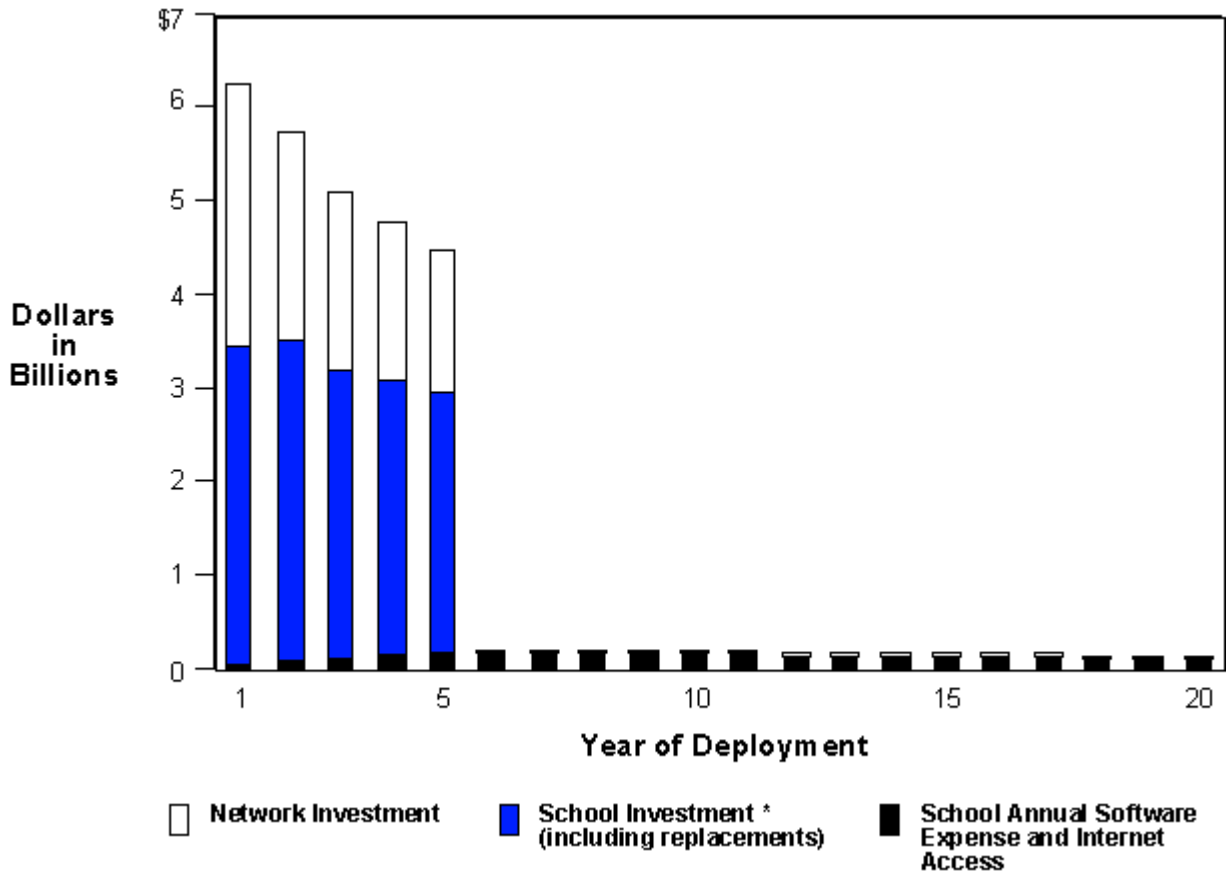


Figure 17: Y-Axis Scaled to Show Detail for Figure 13:
5-Year Accelerated Broadband Deployment, Teacher-Only Access (Scenario 1)



*In the 5-year accelerated deployment, replacement costs for school investment in computers, etc., is minimal in relationship to the initial investment and therefore is not immediately visible in years 6 through 20. Also, modeling the costs out to 20 years allows comparisons with the 20-year deployment.

Figure 18: **Y-Axis Scaled to Show Detail for Figure 14:**
20-Year Broadband Deployment, Teacher-Only Access (Scenario 1)

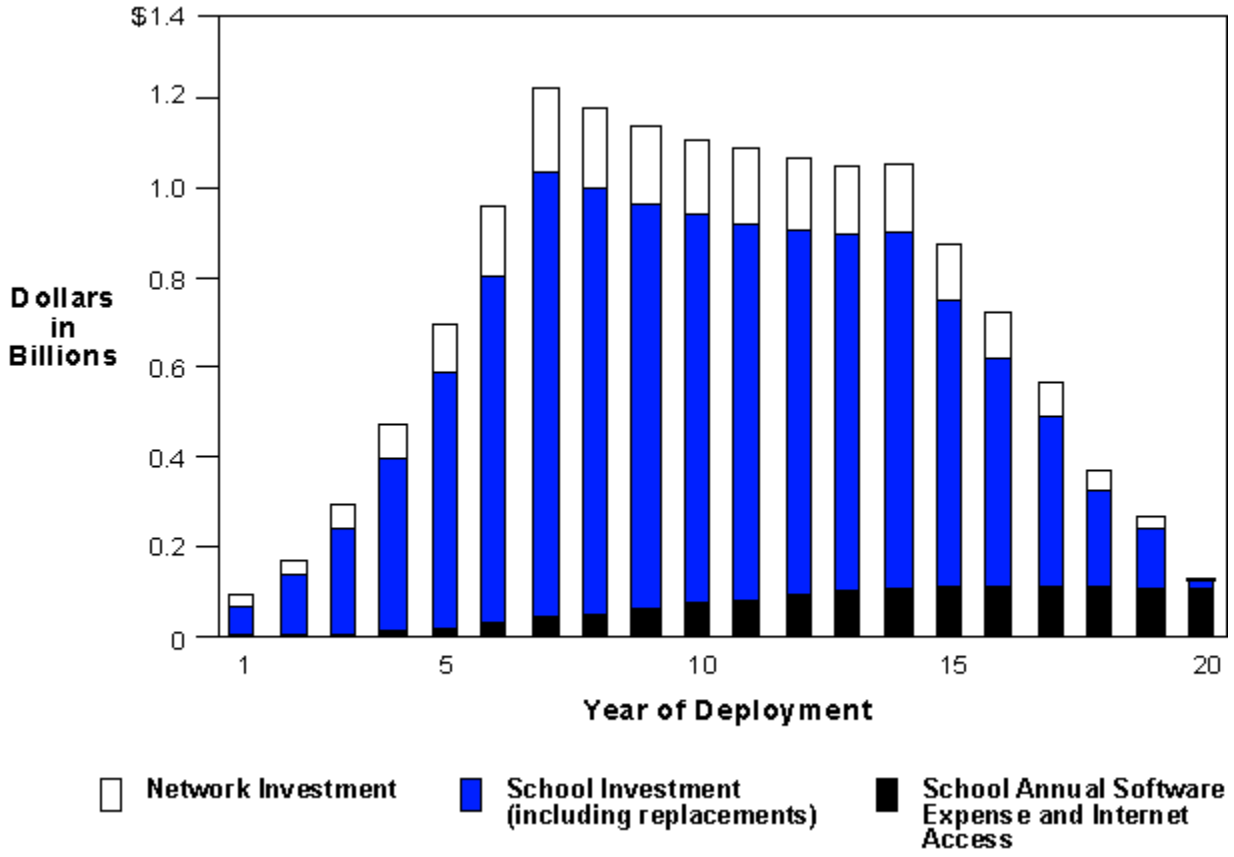
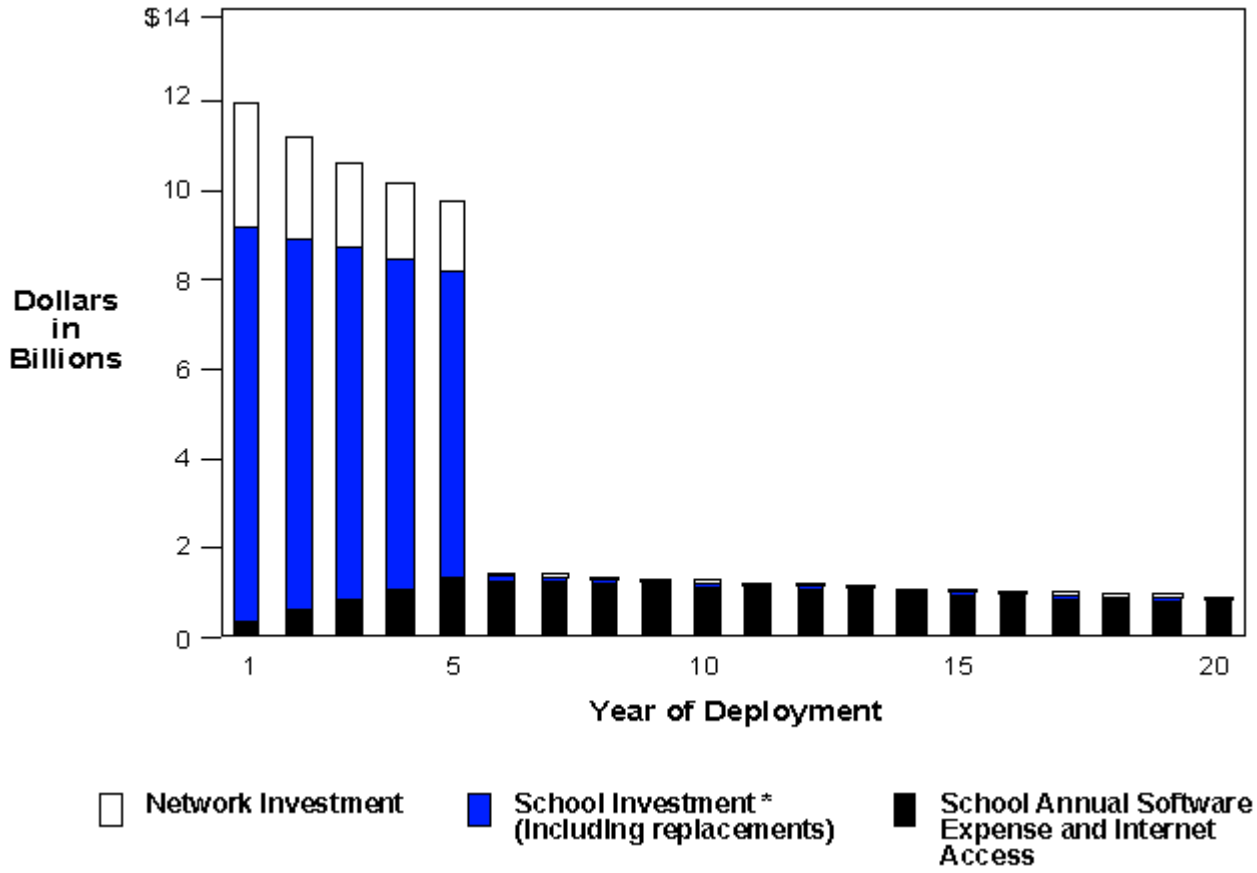


Figure 19: **Y-Axis Scaled to Show Detail for Figure 15:**
5-Year Accelerated Broadband Deployment, Team-of-Students Access (Scenario 2)



* In the 5-year accelerated deployment, replacement costs for school investment in computers, etc., is minimal in relationship to the initial investment and therefore is not immediately visible in years 6 through 20. Also, modeling the costs out to 20 years allows comparisons with the 20-year deployment.

Figure 20: **Y-Axis Scaled to Show Detail for Figure 16:**
20-Year Broadband Deployment, Team-of-Students Access (Scenario 2)

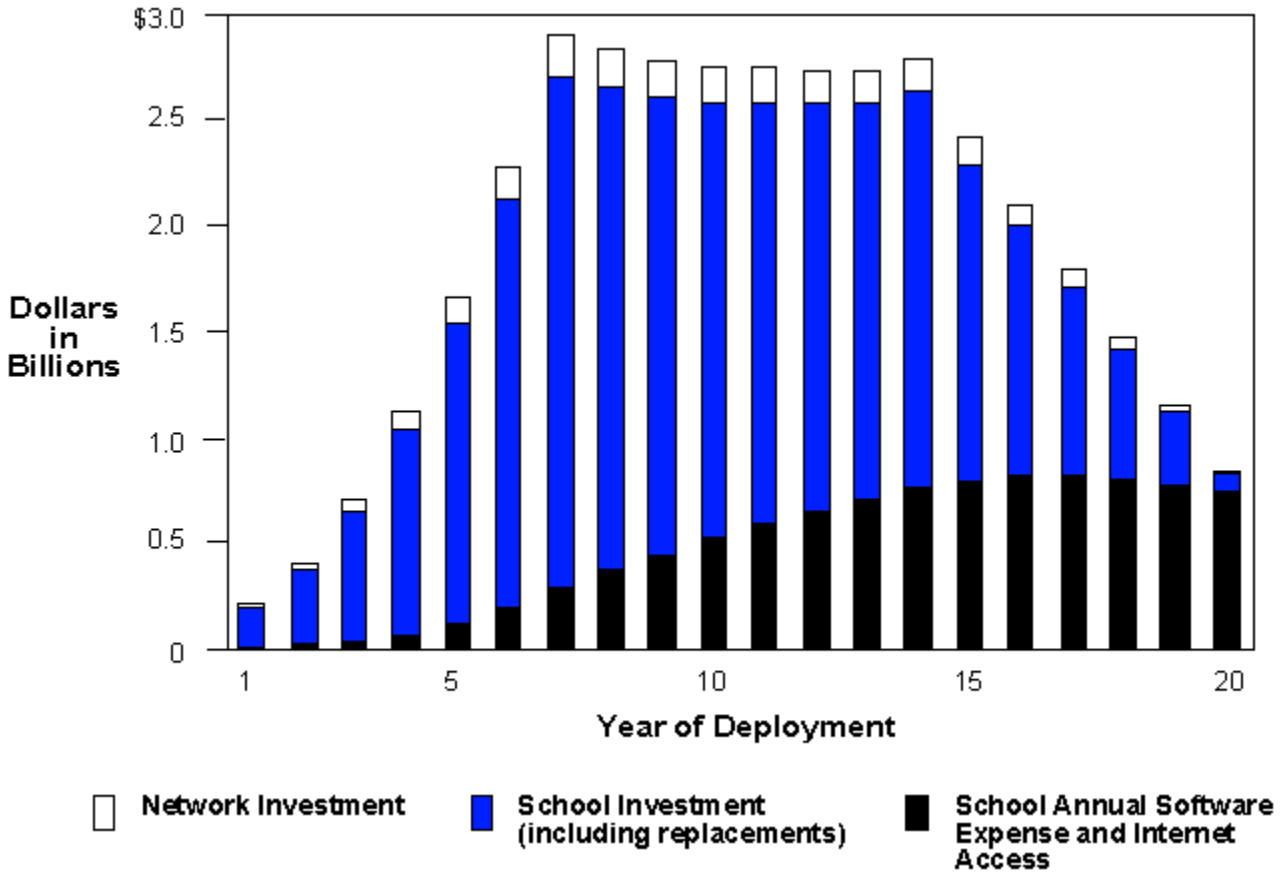
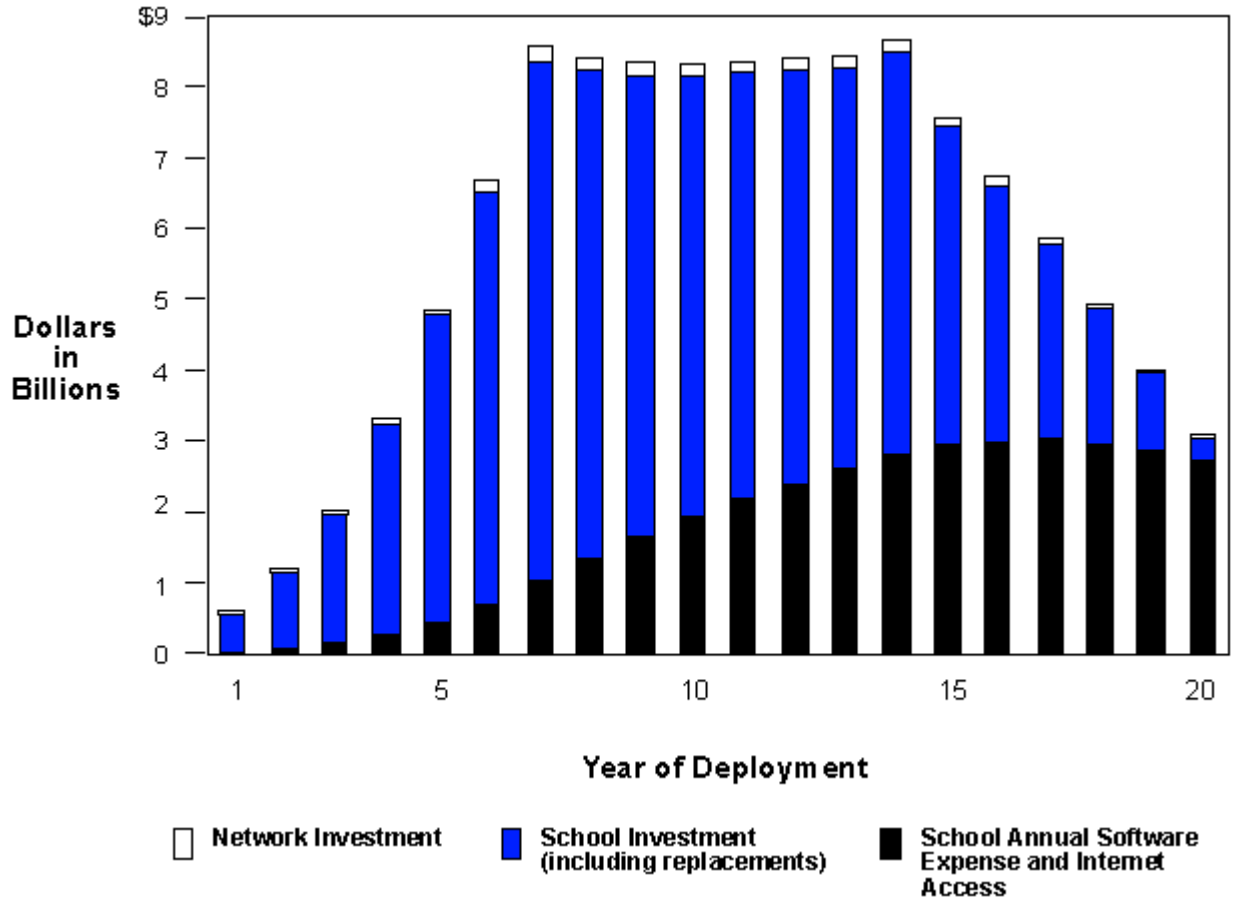
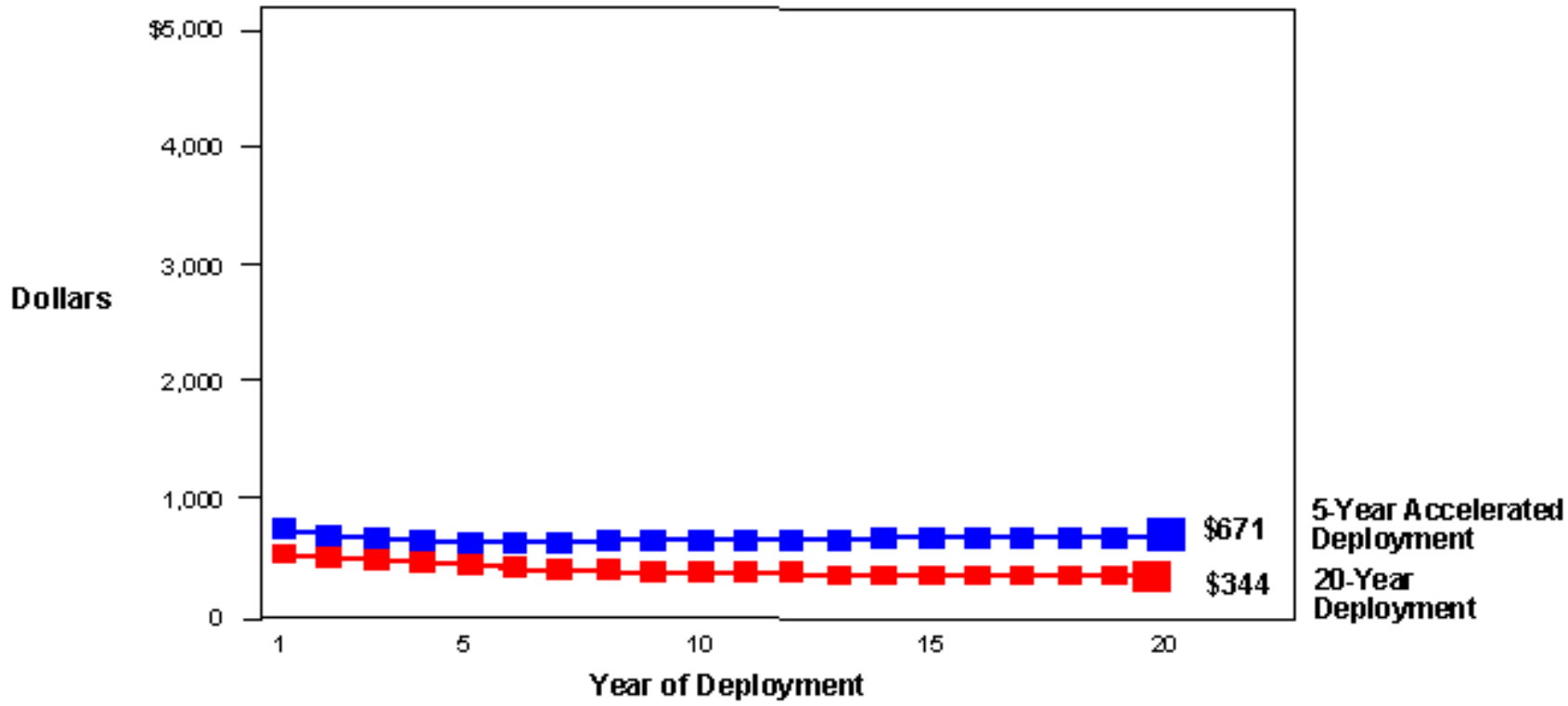


Figure 21: **Y-Axis Scaled to Show Detail for Figure 5: 20-Year Broadband Deployment, Universal Access (Scenario 3)**



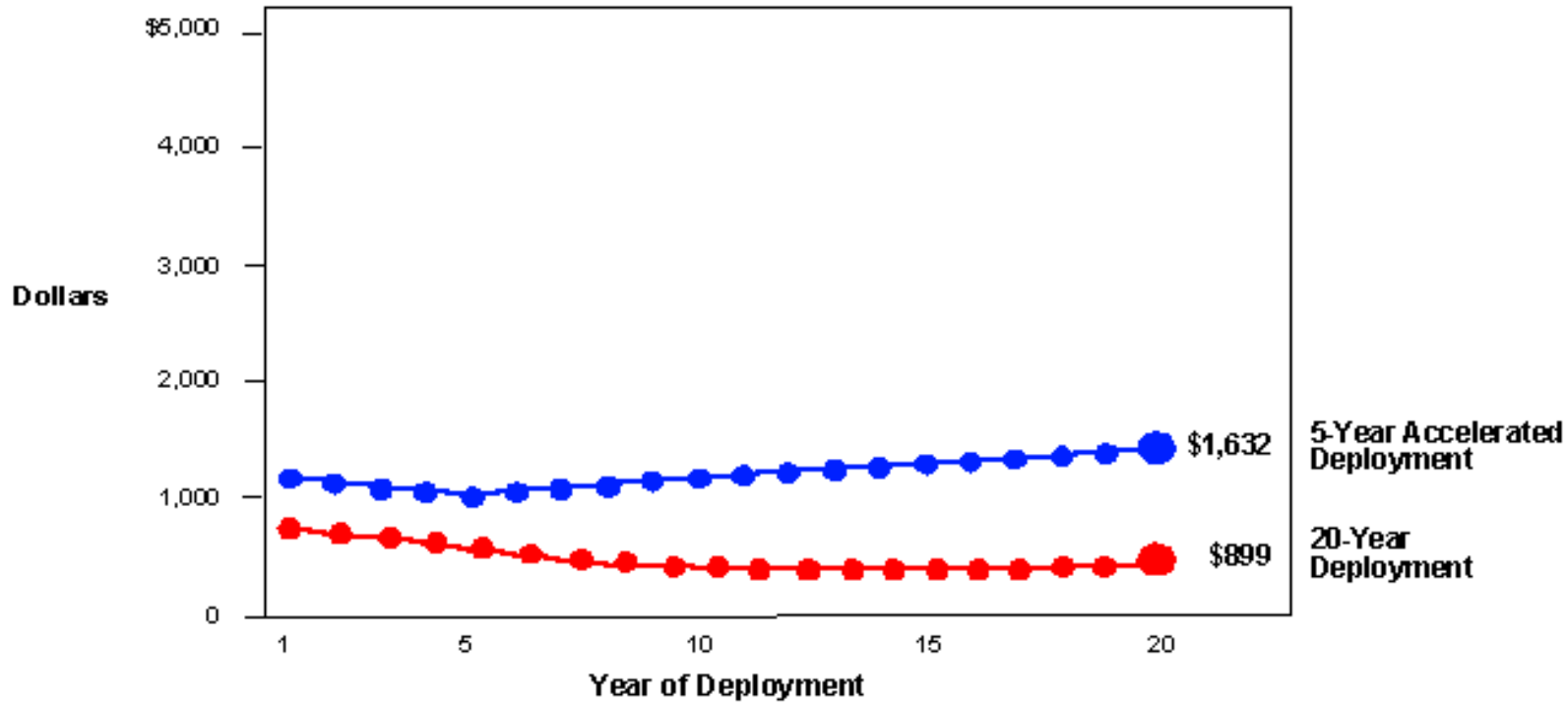
VI. Appendix B: Incremental Investment per Student Charts

Figure 22: **Incremental Investment per Student per Year for Teacher-Only-Access (Scenario 1): 5-Year Accelerated and 20-Year Broadband Deployment**



* Modeling the costs out to 20 years allows comparison between the 5-year accelerated and the 20-year deployment schedules.

Figure 23: **Incremental Investment per Student per Year for Team-of-Students Access (Scenario 2): 5-Year Accelerated and 20-Year Broadband Deployment**



*Modeling the costs out to 20 years allows comparison between the 5-year accelerated and the 20-year deployment schedules.

VII. Appendix C:, Background Data

Figure 24: **Background Data for Figures 13 and 17: Costs by Category for Teacher-Only-Access (Scenario 1), 5-Year Accelerated Broadband Deployment**

Year	Teacher-Only-Access (Scenario 1), 5-Year Accelerated Broadband Deployment		
	School Annual Software Expense and Internet Access	School Investment*	LEC Network Investment
1	$40,185,280	$3,424,273,273	$2,803,925,315
2	78,361,296	3,248,924,084	2,262,052,279
3	114,528,048	3,090,272,143	1,918,999,843
4	148,685,536	2,933,965,065	1,688,112,911
5	180,833,760	2,788,928,573	1,507,575,712
6	175,810,600	21,936,249	0
7	170,787,440	20,046,357	0
8	165,764,280	20,046,357	0
9	160,741,120	18,291,457	0
10	155,717,960	17,650,244	0
11	150,694,800	17,110,274	0
12	145,671,640	16,637,801	0
13	140,648,480	16,232,824	0
14	135,625,320	16,232,824	0
15	130,602,160	15,591,611	0
16	125,579,000	15,355,374	0
17	120,555,840	15,193,384	0
18	115,532,680	15,051,642	0
19	110,509,520	14,950,397	0
20	105,486,360	14,849,153	0
Total	2,672,321,120	15,741,539,086	10,180,666,061

Figure 25: **Background Data for Figures 14 and 18: Costs by Category for Teacher-Only-Access (Scenario 1), 20-Year Accelerated Broadband Deployment**

Year	Teacher-Only-Access (Scenario 1), 20-Year Accelerated Broadband Deployment		
	School Annual Software Expense and Internet Access	School Investment*	LEC Network Investment
1	$843,891	$71,909,739	$20,126,893
2	2,487,971	138,079,274	33,505,081
3	5,382,818	239,496,091	53,502,536
4	10,147,788	387,283,389	82,288,841
5	17,323,874	574,519,286	115,599,889
6	27,285,805	788,422,699	152,537,827
7	40,237,521	1,008,358,356	187,553,881
8	52,381,512	954,654,731	181,971,563
9	63,717,780	912,032,187	174,321,341
10	74,246,323	877,639,250	168,478,386
11	83,967,143	849,731,710	163,806,197
12	92,880,238	826,789,684	159,696,285
13	100,985,609	805,334,173	156,831,364
14	108,283,255	806,218,862	155,386,973
15	113,023,109	645,161,208	128,561,083
16	115,407,101	511,008,359	102,227,500
17	115,637,162	382,486,977	76,320,373
18	113,915,222	212,606,704	50,674,835
19	110,443,214	134,312,448	25,262,798
20	105,486,360	19,339,541	1,128,038
Total	1,354,083,697	11,145,384,666	2,189,781,684

Figure 26: **Background Data for Figures 15 and 19: Costs by Category for Team-of-Students Only-Access (Scenario 2), 5-Year Accelerated Broadband Deployment**

Year	Team of Students-Access (Scenario 2), 5-Year Accelerated Broadband Deployment		
	School Annual Software Expense and Internet Access	School Investment*	LEC Network Investment
1	$281,296,960	$8,823,525,473	$2,803,925,315
2	548,529,072	8,320,387,954	2,262,052,279
3	801,696,336	7,842,232,317	1,918,999,843
4	1,040,798,752	7,355,227,130	1,688,112,911
5	1,265,836,320	6,898,810,138	1,507,575,712
6	1,230,674,200	126,075,282	0
7	1,195,512,080	115,213,411	0
8	1,160,349,960	115,213,411	0
9	1,125,187,840	105,127,389	0
10	1,090,025,720	101,442,111	0
11	1,054,863,600	98,338,720	0
12	1,019,701,480	95,623,252	0
13	984,539,360	93,295,708	0
14	949,377,240	93,295,708	0
15	914,215,120	89,610,431	0
16	879,053,000	88,252,697	0
17	843,890,880	87,321,680	0
18	808,728,760	86,507,039	0
19	773,566,640	85,925,153	0
20	738,404,520	85,343,267	0
Total	18,706,247,840	40,706,768,272	10,180,666,061

Figure 27: **Background Data for Figures 16 and 20: Costs by Category for Team,-of-Students -Access (Scenario 2), 20-Year Accelerated Broadband Deployment**

Year	Team of Students Access (Scenario 2), 20-Year Broadband Deployment		
	School Annual Software Expense and Internet Access	School Investment*	LEC Network Investment
1	5,907,236	185,294,035	20,126,893
2	17,415,798	353,616,488	33,505,081
3	37,679,728	607,773,005	53,502,536
4	71,034,515	970,889,981	82,288,841
5	121,267,119	1,421,154,888	115,599,889
6	191,000,636	1,923,519,064	152,537,827
7	281,662,646	2,427,455,012	187,553,881
8	366,670,587	2,276,048,702	181,971,563
9	446,024,460	2,156,825,613	174,321,341
10	519,724,263	2,062,087,748	168,478,386
11	587,769,998	1,987,513,817	163,806,197
12	650,161,664	1,927,355,636	159,696,285
13	706,899,260	1,867,050,563	156,831,364
14	757,982,788	1,872,135,179	155,386,973
15	791,161,765	1,490,240,093	128,561,083
16	807,849,707	1,187,566,770	102,227,500
17	809,460,132	901,842,942	76,320,373
18	797,406,557	614,684,473	50,674,835
19	773,102,500	348,266,451	25,262,798
20	738,404,520	92,328,569	1,128,038
Total	9,478,585,880	26,673,649,028	2,189,781,684

*Includes Replacements

Figure 28: **Background Data for Figures 4: Costs by Category for Universal Access (Scenario 3), 20-Year Accelerated Broadband Deployment**

Year	Universal Access (Scenario 3), 5-Year Accelerated Broadband Deployment		
	School Annual Software Expense and Internet Access	School Investment*	LEC Network Investment
1	$1,044,817,280	$26,891,852,591	$2,803,925,315
2	2,037,393,696	25,358,513,525	2,262,052,279
3	2,977,729,248	23,877,128,176	1,918,999,843
4	3,865,823,936	22,352,345,187	1,688,112,911
5	4,701,677,760	20,918,934,791	1,507,575,712
6	4,571,075,600	455,848,884	0
7	4,440,473,440	416,575,749	0
8	4,309,871,280	416,575,749	0
9	4,179,269,120	380,107,839	0
10	4,048,666,960	366,783,025	0
11	3,918,064,800	355,562,130	0
12	3,787,462,640	345,743,846	0
13	3,656,860,480	337,328,174	0
14	3,526,258,320	337,328,174	0
15	3,395,656,160	324,003,361	0
16	3,265,054,000	319,094,219	0
17	3,134,451,840	315,727,950	0
18	3,003,849,680	312,782,465	0
19	2,873,247,520	310,678,547	0
20	2,742,645,360	308,574,629	0
Total	69,480,349,120	124,701,489,012	10,180,666,061

*Includes Replacements

Figure 29: **Background Data for Figures 5 and 21: Costs by Category for Universal Access (Scenario 3), 20-Year Broadband Deployment**

Year	Universal Access (Scenario 3), 20-Year Broadband Deployment		
	School Annual Software Expense and Internet Access	School Investment*	LEC Network Investment
1	21,941,163	564,728,904	20,126,893
2	64,687,250	1,077,736,825	33,505,081
3	139,953,275	1,850,477,434	53,502,536
4	263,842,484	2,950,509,565	82,288,841
5	450,420,729	4,309,300,567	115,599,889
6	709,430,933	5,819,211,459	152,537,827
7	1,046,175,542	7,332,166,341	187,553,881
8	1,361,919,324	6,873,693,536	181,971,563
9	1,656,662,279	6,513,796,440	174,321,341
10	1,930,404,407	6,229,521,604	168,478,386
11	2,183,145,707	6,008,471,759	163,806,197
12	2,414,886,179	5,831,566,209	159,696,285
13	2,625,625,825	5,649,199,437	156,831,364
14	2,815,364,643	5,667,583,822	155,386,973
15	2,938,600,841	4,517,635,407	128,561,083
16	3,000,584,626	3,611,428,630	102,227,500
17	3,006,566,205	2,757,763,146	76,320,373
18	2,961,795,784	1,923,492,620	50,674,835
19	2,871,523,571	1,096,336,779	25,262,798
20	2,742,645,360	326,621,520	1,128,038
Total	35,206,176,127	80,911,192,004	2,189,781,684

*Includes Replacements

Figure 30: **Background Data for Figures 6, 7, 8, 22, and 23: Incremental Investment per Student by Deployment Schedule for All Three Scenarios**

	5-Year Accelerated Broadband Deployment			20-Year Broadband Deployment		
Year	Scenario 1: Teacher Only Access	Scenario 2: Team of Students Access	Scenario 3: Universal Access	Scenario 1: Teacher Only Access	Scenario 2: Team of Students Access	Scenario 3: Universal Access
1	$735	$1,396	$3,604	$519	$1,180	$3,388
2	$695	$1,351	$3,541	$493	$1,137	$3,292
3	$664	$1,313	$3,485	$470	$1,093	$3,182
4	$638	$1,281	$3,432	$449	$1,048	$3,059
5	$615	$1,251	$3,382	$429	$1,003	$2,937
6	$620	$1,283	$3,499	$411	$962	$2,822
7	$624	$1,314	$3,613	$374	$922	$2,712
8	$629	$1,344	$3,724	$382	$897	$2,646
9	$633	$1,373	$3,831	$372	$879	$2,603
10	$637	$1,400	$3,935	$365	$866	$2,574
11	$641	$1,428	$4,035	$358	$857	$2,554
12	$645	$1,454	$4,132	$353	$849	$2,541
13	$648	$1,479	$4,225	$348	$843	$2,532
14	$652	$1,503	$4,316	$344	$840	$2,531
15	$655	$1,527	$4,403	$342	$840	$2,540
16	$659	$1,550	$4,487	$340	$845	$2,564
17	$662	$1,571	$4,568	$340	$853	$2,599
18	$665	$1,592	$4,646	$340	$865	$2,646
19	$668	$1,613	$4,721	$342	$880	$2,704
20	$671	$1,632	$4,792	$344	$899	$2,774
Total	$13,052	$28,654	$80,372	$7,735	$18,558	$55,201