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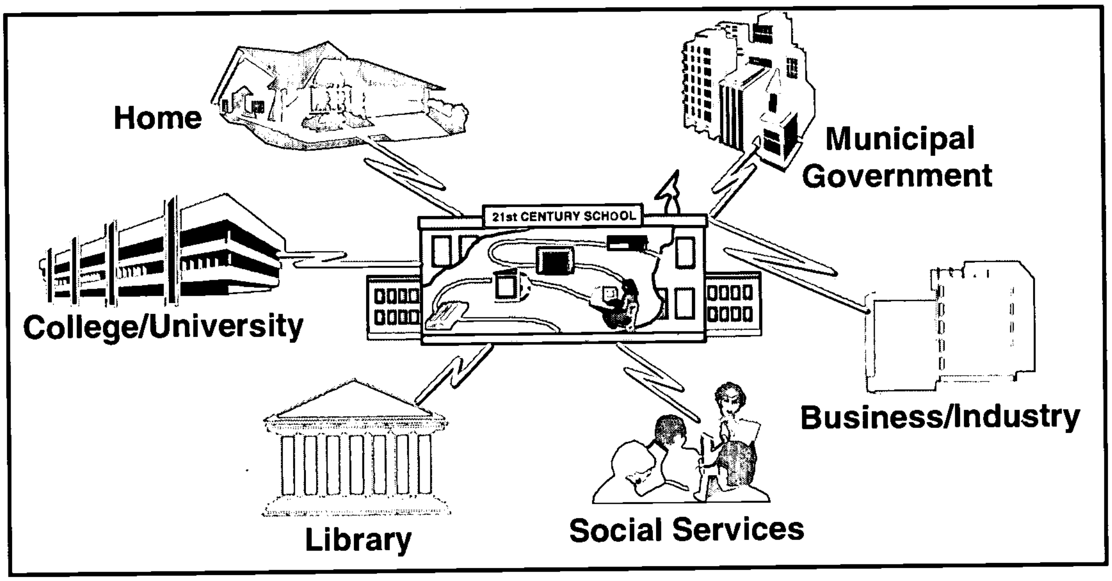
ABSTRACT

This document presents guidelines and recommendations for development of a technology infrastructure in Connecticut public schools that conforms to national industry standards for voice, video, and data communications. The guidelines present information on the state statutes regarding facilities implementation and describe industry standards. Provided are the technical wiring and cabling information, design options, and recommended guidelines for implementation. Also provided are recommendations for voice, video, and data systems including a model for integrated bell, clock, paging, and media access/retrieval systems. Technology recommendations for various types of classrooms and work areas are included. What type of impact these changes present for both existing and new schools is described; and a variety of options, strategies, and considerations that could be used for designing/supporting a wide range of technology capabilities that best serve most school needs are discussed. A series of appendices include a glossary, a 15-item bibliography, sample facility layouts, and an overview of EIA/TIA standards. (GR)

Guidelines for Technology Infrastructure in Connecticut Schools

An Implementation Guide for the *Connecticut Statewide Educational Technology Plan*



CONNECTICUT STATE DEPARTMENT OF EDUCATION

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December 15, 1995

State of Connecticut

John G. Rowland, Governor

State Board of Education

Theodore S. Sergi
Commissioner of Education

Benjamin Dixon
Deputy Commissioner of Education

ACKNOWLEDGMENTS

The guidelines contained in this document are not static; they have evolved over the past year from the work of a State Department of Education committee comprised of educators, design professionals, and technicians. We are grateful for the extensive time and effort dedicated by many people and for the gracious welcome we received in several towns and districts when we met at model schools to sample representative technology installations. It is certain that the list of Connecticut schools having state-of-the-art technology will continue to grow.

The Standards Committee acknowledges the cooperation and assistance of Commissioner Sergi and Carol Rocque, technology coordinator for the State Department of Education. We also acknowledge and thank the staff members at the Center for Educational Leadership and Technology (CELT) who were responsible for the final organization and publication of this document.

The Guidelines Committee welcomes your comments. Because technology continues to evolve, we expect to update these guidelines annually.

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FOREWORD

Technology and telecommunications have revolutionized almost every aspect of American life. They have transformed the way we do business and communicate, our health care, science and agriculture, and to some degree our educational system. Technology enables not only local or regional interaction, but also worldwide communications, providing linkages to peoples and countries at the touch of a button. We truly live in an information age.

Many of the changes that characterize our daily lives have not yet made a significant impact on our schools. While there are numerous reasons for this gap between what is used in society and what is used in our schools, one contributing factor is school facilities. The school plant can act as a barrier to the effective integration of educational technology and telecommunications into teaching and learning. The results of a survey conducted by the Connecticut Education Association in 1993 indicates that only 17 percent of the state's schools are less than 25 years old. Existing wiring in many buildings cannot accommodate the high-speed, high-volume technology needed for modern telecommunications. Financial resources needed to make the major renovations necessary to implement fully educational technology in a school can put substantial strain on district or town budgets. However, education must change to integrate fully a wide range of learning resources and educational technology---including telecommunications---if our students are to be competitive in their educational endeavors and in the job market.

There are Connecticut schools using educational technology in a variety of ways. Most of these 21st-century schools were the result of local initiative and individuals who developed applications of technology to the school curriculum. Until now, there has been no broad-based application of technology or infusion of financial support for the major renovations that are often necessary to integrate fully educational technology into teaching and learning on an equitable basis throughout the state.

New regulations are being developed to ensure the equitable access to information and technology by all students and teachers. The purpose of this document is to provide educators and architects with the technical standards for providing voice, video, and data communications capability in every classroom and to establish a framework school personnel can use to plan for the effective use of educational technology. Technology is not an end in itself. Technology provides the gateways to information and resources that allow individuals to:

- locate, retrieve, and/or store information in a wide range of formats
- communicate through a variety of information formats
- teach and/or learn with diverse approaches and styles

This document is the first step in providing state leadership and assistance to Connecticut districts in educational technology. We trust its use will be helpful in developing plans and implementing technology in schools throughout the state.

Theodore S. Sergi
Commissioner of Education

EXECUTIVE SUMMARY

States across the nation are recognizing the need for increased planning to ensure effective and cost-efficient use of technology for enhanced productivity and, ultimately, improved student performance. So too, Connecticut acknowledges that establishing clear guidelines for a technology infrastructure that will support a full range of applications will help ensure the cost-effective infusion of technology in all Connecticut schools. Technology is a powerful tool for moving the state toward a world-class educational system.

To assist with these efforts, the Department of Education has contracted with the Center for Educational Leadership and Technology (CELT) to assist the existing Educational Technology Standards Committee (composed of Department of Education staff, local and state educators, design professionals, technology experts, and members of the business community) in the development of the *Guidelines for Technology Infrastructure in Connecticut Schools* This document expands on the steps for implementing the comprehensive technology infrastructure recommendations contained in the *Connecticut Statewide Educational Technology Plan* Implementation of these recommendations necessitates statewide guidelines for voice, video, and data communications and accompanying facility requirements in such areas as curriculum-specific facilities requiring extensive technology; heating, ventilation, and air conditioning (HVAC); electrical power; and environmental and general space recommendations. Guidelines include consideration for new and major renovation projects to ensure that technology is included in all school facility design projects.

This publication is influenced by the following statements and is intended to give direction to educational communities as they seek to improve the quality of teaching and learning through the integration of technology.

- Education must be responsive to the demands created by our technology-rich, information-intensive society.
- Technology can assist in actively engaging students in the learning process.
- Schools must provide the physical environment and infrastructure that enables maximum and effective integration of information and technology for teaching and learning.

A link exists between the school facility and the ability to make the above statements a reality for Connecticut students. The following 11 statements represent the Educational Technology Standards Committee's beliefs regarding the role of technology for education and the requirements for school facilities.

1. Every student, teacher, classroom, school, and district should have access to and make effective use of appropriate and up-to-date learning resources that include access to voice, video, and data information via telecommunications.
2. Telecommunications can bring distant information resources, courses, programs, and professional development to our schools and make connections among schools, libraries, homes, and businesses. These linkages with other sources of information and learning environments---domestic or foreign, private or public---are beneficial to learners and educators.

3. School facilities should have the technology infrastructure necessary to facilitate administration, enable higher levels of learning for all students, provide access to extensive learning resources and information, and support creative and accountable instruction.

4. Literacy in our information- and technology- rich society requires that individuals not only be able to read and write, but also to employ effectively and efficiently information and technology for learning, research, problem solving, transition to work, and communications.

5. Because technology and telecommunications are so prevalent in our society, it is essential that all students and teachers have the opportunity to learn about and use a wide range of information technologies, beginning in elementary school and continuing through high school.

6. All school construction or renovation projects should include provisions to enhance access to and use of educational technology.

7. Technology will continue to change rapidly. School facilities must be capable of adapting to new and emerging technological advances while maintaining and servicing existing systems.

8. The State Department of Education has a responsibility to provide guidance to school districts in designing school facilities that support access to a wide spectrum of information, incorporate a full range of technology and telecommunications, and guarantee each student and teacher the opportunity to learn about and use information and technology.

9. Staff with appropriate education and training is necessary for effective management, implementation, integration, and utilization of learning resources and technology. Ongoing staff development is critical to ensure that educational technology becomes an effective tool for teaching and learning in all disciplines.

10. Equitable access to information and technology by teachers and students is a key factor in improving the quality of education in our state, promoting economic growth, and developing an enlightened citizenry for the 21st century.

11. Schools should provide for the maintenance and servicing of technology resources, equipment, and systems.

All guidelines and recommendations presented in this report are in accordance with Connecticut General Statutes and conform to national industry standards for voice, video, and data communications. All recommendations for the wiring and video infrastructure abide by the following major industry guidelines: Electronics Industry Association/Telecommunications Industry Association (EIA/TIA) standards, Federal Communications Commission (FCC) regulations, cable industry practices, and Institute of Electrical and Electronic Engineers (IEEE) code.

Recommendations support a multiproduct, multivendor environment and facilities, and, to the greatest extent possible, the processes of upgrading and maintaining equipment.

The following table summarizes the recommended **minimum** infrastructure wiring standards.

Infrastructure Area	Component	Data	Voice	Video
Work Area	Connector	RJ-45	RJ-45	F Connector
	Pinning	EIA/TIA 568-A	EIA/TIA 568-A	N/A
	Face Plate	Four (4) Composite		
	Distribution	One per Work Area		
	Mounting	Permanent / Wall Mount		
Horizontal	Cable	Level 5 UTP	Level 5 UTP	RG-6
	Conductor	4-Pair (8 Conductor)	4-Pair (8 Conductor)	1
	Install	Conduit/ Cable Tray/Hidden		
Distribution Frame	Patching Connector	RJ-45	RJ-45	N-Type
	Punch Down	110 Type	110 Type	N/A
	Mounting	Wall/Cabinet		
Backbone	Cable Type	Fiber Optics	Level 5 UTP	RG-11
	Conductor	12 Strand	100 Pair	1
	Connector	ST-Type	Amp 50 pin	N-Type
	Mounting	Conduit/ Cable Tray		
Campus Backbone	Cable Type	Multimode Fiber Optic	Level 5 UTP	RG-11
	Conductor	12 Strand	100 Pair	1
	Connector	ST-Type	Amp 50 pin	N-Type
	Mounting	Conduit/ Overhead Pole /Direct Burial		

The *Guidelines for Technology Infrastructure in Connecticut Schools* is divided into two major parts. Part A, "Facility Design," is organized into six major sections: Introduction, State Statutes and Industry Standards, Technology Wiring Infrastructure, Technology Systems, Technology Guidelines for Specific School Areas, and Impact on School Facility Design.

Section 1, "Introduction," provides an overview of the document and describes the Connecticut State Department of Education's beliefs regarding the role of technology in learning and school facilities.

Section 2, "State Statutes and Industry Standards," provides the state law regarding facilities implementation and describes the EIA/TIA and FCC standards.

Section 3, "Technology Wiring Infrastructure," provides technical wiring and cabling information, design options, and recommended guidelines for implementation.

Section 4, "Technology Systems," provides recommendations for voice, video, and data systems as well as a model for integrated bell, clock, paging, and media access/retrieval systems.

Section 5, "Technology Guidelines for Specific School Areas," provides recommendations for various types of classrooms (i.e., science, art) as well as work areas (i.e., teacher presentation area, student work group area). Guidelines for the library media center, computer lab, administrative office area, and school service area infrastructures are also provided.

Section 6, "Impact on School Facility Design" describes the impact of changes made to present systems for both existing and new schools. For existing schools, this would concern renovation, electrical update requirements, room lighting, building and equipment security. For new schools, this would deal with design and construction options, space allocation, acoustics, and planning for future expansion.

Part B, "Facility Options and Recommendations," outlines a variety of options, strategies, and considerations that could be used for designing/supporting a wide range of technology capabilities and recommends the one that will best serve most school needs. A rationale for each recommendation is included. Major sections include: Introduction; Criteria; Local-Area Network Options; and Other Considerations (Electrical Power, Furniture, and Space Strategies, Heating, Ventilation, and Air Conditioning, and Other Environmental Issues).

A series of appendices include a Glossary of Terms, Bibliography, Sample Facility Layouts, and Overview of EIA/TIA Standards. They will assist facility planning teams in designing a technology infrastructure that will serve their community.

The infrastructure guidelines provide recommendations that will serve as the foundation for a comprehensive, integrated information technology system. The goal is expanded and equitable capacity for using technology and telecommunications for teaching and learning in all Connecticut schools. A carefully planned and installed technology infrastructure can move our educational systems toward this goal through greater system and organizational efficiency; improved teaching and learning environments; increased access to information by students, teachers, and instructional staff; expanded connectivity to the community; support for lifelong learning; and updated communication channels. The guidelines will help create the opportunity for all Connecticut students to achieve proficiency in using the technology tools they need to be successful and productive citizens.

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Part A:

Facility Design

1. INTRODUCTION

Sections 10-287c and 10.42 of the Connecticut General Statutes authorize the State Board of Education to prescribe rules and regulations necessary to the implementation of a school construction grant program.

This document is intended to provide school personnel and design professionals with a sufficient degree of technology awareness and design guidance in order to assist the process of facility infrastructure planning, design, and specification.

For the purposes of this document, the broad definition of educational technology adopted by the Joint Committee on Educational Technology will be used:

> "Educational technology is the design, development, use, management and evaluation of processes and resources for learning. It includes but is not limited to the following kinds of delivery systems: computer-based systems; devices for storage, retrieval and delivery of massive amounts of information; and telecommunications for the audio, video, information sharing and other electronic media which may be devised by the year 2000. Educational technology is most appropriately and effectively utilized when it is integrated into the teaching and learning and management process for Connecticut citizens, preschool through adult, in both formal and informal settings."

1.1 Integrating Technology into the Process of Education

Figure 1-1 describes a typical infrastructure planning approach to establishing a process for integration of technology into the school environment. This document addresses the following two steps of this approach:

- Determine functional requirements.
- Set architectural standards and design parameters.

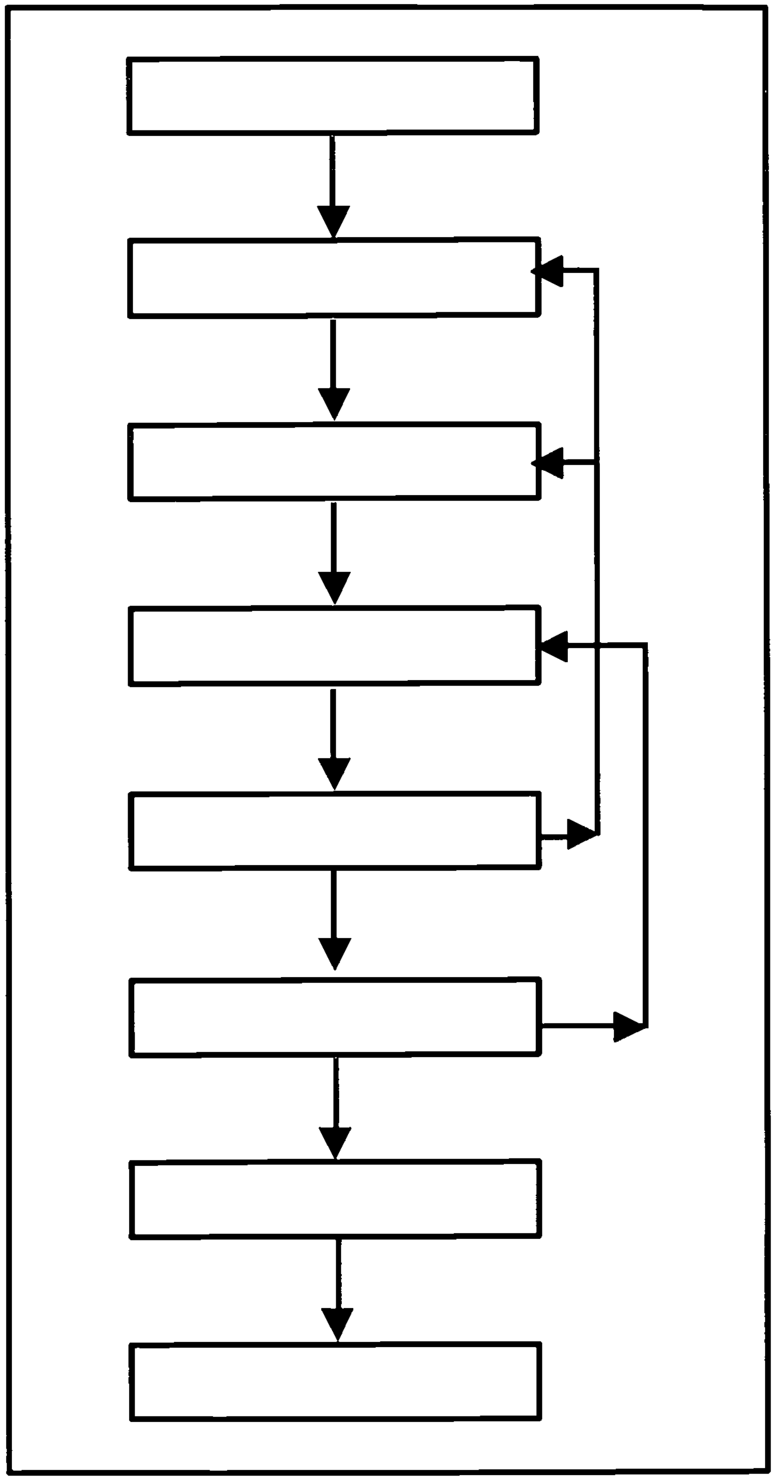

Figure 1-1: Infrastructure Planning Approach

2. STATE STATUTES AND INDUSTRY STANDARDS

2.1 State Statutes and Requirements

Sec. 10-287c-1. Definitions

(c) **"Educational Specifications"** means a description of the general nature and purpose of the proposed school building project, which may include the applicant's long-range educational plan and the relationship of the proposed project to that plan; enrollment data and proposed project capacity; the nature and organization of the educational program; support facilities; space needs; accommodation for educational technology; specialized equipment and site needs; and any other supporting documents deemed necessary by the commissioner.

Sec. 10-287d-15. Standards

(d) **Ineligible Costs.** Eligible costs do not include: feasibility studies; textbooks and supplies; computer software, except computer operating systems; lease of facilities (other than in accordance with subdivision (9) of subsection (a) of Section 10-286 of the Connecticut General Statutes); service, equipment, or maintenance contracts; salaries of "in-house" administration or educational staff employed by the local board of education or municipality; site regarding ordinary resurfacing or re-seeding; relocation of facilities within site; repair of site improvements; athletic facility lighting; athletic facility parking; artificial turf; off-site town improvements and utility extensions; moving of existing facilities on-site or to another site (except where necessary for a new school plant or extension); ordinary building and built-in equipment maintenance, repair, repainting, or redecoration; repair to movable equipment and furniture; ordinary repairs to or replacements of boilers; combustion equipment or fuel equipment; ordinary roof repairs or replacements not specifically eligible under Section 10-286(a)(7) of the Connecticut General Statutes; ordinary window or glass replacements; and other ordinary repairs and replacements.

State Grant Reimbursement

State grant reimbursement for educational technology is available when a town or district undertakes a new construction, addition , or major renovation project. Under the present law (Section 10-282 (c) of the Connecticut General Statutes) , equipment costs, including equipment for educational technology, are only reimbursable pursuant to a major construction or renovation project.

Public Act 95-272, which was recently enacted by the Connecticut General Assembly, provides for a competitive grant program to be administered by the State Department of Education to provide funding for wiring, cable, or other distribution systems and infrastructure improvements to support telecommunications and other information transmission equipment to be used for educational proposes. This legislation specifically does not permit state grant funding for computer equipment, except in connection with a major project. Projects with limited construction (i.e., the wiring of a single classroom to accommodate the installation of computers) will not be treated as a major renovation of the facility for purposes of computer equipment eligibility.

All construction and renovation projects must be in compliance with all applicable codes, including wiring for technology. For example, the interstitial space above corridor ceilings is sometimes used as a return air plenum. Combustible material is not allowed within this area, including wiring, unless it has a special rated jacket and/or is installed within rated tubing. Another concern is whether the system (wiring/conduits, etc.) is penetrating any fire rated assemblies, thus requiring fore-safing protection. Some areas within the building may not permit penetrations for these systems. Some buildings may be so advanced in age, that to rewire an entire building for technology systems may require additional work which warrants a code review of the entire facility. Because no building can be legally occupied in Connecticut except in compliance with all applicable codes, it is important to address code issues before or during any project to provide the tools for technology.

Finally, if the roof is leaking or deteriorated, it should be clear and obvious that this must be corrected before the installation of any new electrical wiring for technology or any other purpose.

American With Disabilities Act (ADA)

All public primary and secondary schools in Connecticut are subject to the requirements of Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act (ADA). The School Facilities Unit of the State Department of Education implements these requirements in the review of all construction and renovation documents in cooperation with the U.S. Office for Civil Rights in Boston. Federal law also requires that districts do a self-evaluation, develop an action plan, and be in compliance with accessibility standards by January 26, 1995.

The superintendent of schools must designate which schools in the district are accessible. A "designated" school is a facility in which **all programs and activities** are completely accessible to persons with disabilities, including students, faculty, parents, and visitors. Facilities that are "substantially" or "almost totally" accessible do not qualify as "designated" facilities. In the absence of the district's federally required self-evaluation of accessibility needs, SDE recommends that 50 percent of the elementary, middle, and secondary schools in the district be accessible to persons with disabilities. Nondesignated schools are required to make these programs and activities accessible if a student, parent, or visitor with a disability wants to attend.

Under law, **all new construction must be completely accessible**. Renovations to existing buildings totaling more than 50 percent of the value of such buildings must also include complete accessibility.

2.2 Conformity to Industry Standards

Infrastructure systems for schools and districts will be based on the Electronics Industry Association/Telecommunications Industry Association (EIA/TIA) building telecommunications wiring standards. Video systems will be based on the Federal Communication Commissions (FCC) regulations pertaining to building-level CCTV signal emissions. These standards are designed to provide guidelines for installing wiring systems that will prove effective and adaptable over time and will support a multiproduct, multivendor environment.

Most EIA/TIA standards are reviewed every five years and standards are retained, revised, or deleted. A listing of the standards most applicable to school construction and renovation can be found in Appendix D, "Overview of EIA/TIA Standards." Consult Appendix B for bibliographic information on the entire set of standards.

2.3 Accommodation for Educational Technology

"Accommodation for educational technology" means that each school shall be required to provide an infrastructure to support the transmission of voice, video, and data to each learning and administrative area of the school. Infrastructure shall be defined as the means to transmit and receive voice, video, and data signals and can include wire, fiber optics, radio frequency, infrared, or any other pathway that can be demonstrated to accomplish the same.

2.4 Carrying Capacity

The technology infrastructure in a school must be capable of supporting a transmission capacity (bandwidth) of not less than 100 megabits per second for voice and data. In addition, the video component of the network must have sufficient bandwidth to support multichannel full-motion video. These capabilities must exist as networks throughout the school. The minimum infrastructure for voice and data shall be Level 5 unshielded twisted pair wires. In order to meet this requirement, the minimum infrastructure for video will be RG-6 coaxial cable.

3. TECHNOLOGY WIRING INFRASTRUCTURE

3.1 Basic Versus Integrated Technology Infrastructures

There are many aspects to establishing a technology infrastructure that meets the needs of a particular school facility. However, for the purposes of assisting schools to focus more clearly on the important issues, this document presents two (2) categories of infrastructure design:

- basic voice, video, and data infrastructure
- integrated technology infrastructure

The following paragraphs describe these two designs and the specific advantages and disadvantages of each.

Basic Voice, Video, and Data Infrastructure

The basic voice, video, and data infrastructure comprises a structured wiring design for both voice and data communications with a bidirectional broadband design for video information delivery and propagation throughout the entire school facility. This design approach is intended to supply the technology access that meets the educational needs of the school. The basic approach is the most economical design for schools that are considering renovations that do not include replacement of bell, paging, or media retrieval systems. It provides flexible integration of voice, video, and data services throughout the facility. It also provides a means to reconfigure the distribution of voice and data services using distribution frame cross-connect patch panels. Section 3.2, "Facility Layout Basics and Guidelines," will elaborate the specific features and advantages of structured wiring.

Integrated Technology Infrastructure

The integrated technology infrastructure incorporates not only all of the basic systems identified above but also the school's other communication systems such as clock, bell, paging, and media control and retrieval. This approach is recommended:

- for new facilities
- for facilities being completely renovated
- for facilities planning the replacement of existing bell and paging systems

3.2 Facility Layout Basics and Guidelines

Facility layout guidelines are based on the use of conventional cabling practices and industry standards in order to ensure that infrastructures acquired are uniform and certifiable. The use of EIA/TIA standards are recommended as they provide the most functional and cost-effective infrastructure specification for voice and data communications. The video infrastructure is based on current cable television and Federal Communication Commission (FCC) requirements for closed circuit television (CCTV) electromagnetic radiation emission standards. While it is not necessary for the schools to be versed in the detail of these standards, it is important that they be aware of them and their importance to the acquisition of a dependable information delivery system for the school facility.

3.2.1 Structured Wiring Basics

A structured wiring system for the distribution of voice and data communications provides a flexible communications infrastructure for school facilities. School room assignments and utilization are always in a state of flux. The need to have an infrastructure that can be easily reconfigured cannot be understated. Structured wiring alleviate s problems of building communication cabling reassignment that facilitates the relocation of facility communications by means of simple, no-tools-required, patch cables. Thus, voice and data resources can be connected to any given outlet receptacle anywhere in the facility. The following section describes the specifics of this design approach and details the standards the are required to ensure its proper installation and certification. Additional design options and technology awareness information can be found in Part B of this report, "Facility Options and Recommendations."

3.2.2 Building Cabling Design

The minimum cabling standards for the technology network infrastructure are based on two requirements. First, the standards must accommodate present and future needs. Second, the technology network infrastructure must support voice, video, and data communications using a variety of transmission methods. Following are the design objectives of the technology network infrastructure:

- Connection to the communications wiring must be simple and require no tools or special training.
- The wiring must be safe and meet or exceed all local building codes for safety, including Underwriters Laboratory (UL) testing standards for flammability and low smoke. The cable plant must not emit harmful levels of electromagnetic radiation.
- The wiring system should be available at a low cost and from multiple vendors to encourage competitive pricing.
- The technology infrastructure must accommodate additions and changes to initial outlet assignments and permit workstations and other devices to be moved easily from one location to another.
- The technology infrastructure should support existing communications equipment and local-area networks (LANs).
- The cabling scheme must allow multiple connections per classroom or work area.
- The technology infrastructure must support the current highest feasible speeds.

3.2.3 EIA/TIA 568 Specification for Commercial Building Cable Systems

The Electronic Industries Association/Telecommunication Industries Association (EIA/TIA) 568 specification and related cable management and testing specifications have been developed specifically to provide a certifiable technology infrastructure installation that is independent of transmission protocol and encompasses a range of cabling schemes.

This specification defines categories of cables representing different data speed ratings developed for commercial building telecommunication wiring. The primary advantage of EIA/TIA 568 is that it is an open standard. Cables can be selected and specified to meet the specific category of the standard and elicit comparable bids from a variety of vendors. Additionally, it is protocol independent. Thus, the selection of a data transmission scheme can be made independently from the cable plant design as long as the speed of communications is supported by the cable category level selected for installation.

The EIA/TIA standards define performance installation and testing specifications of the cable. The current recommendation calls for at least two cables to be run to each user location: one to support data and the other to support voice communications. The versatility of this cabling standard also allows the interchange of cable assignment when required. For example, a cable initially assigned as a voice cable could be reassigned as a data cable if the need arose. This standard supports the inevitable need to make additions and changes to the installed cable plant. Figure 3-1 depicts the arrangement of the building cables run to the MDF with cables attached. It also illustrates versatility of being able to assign any system resource to a specific room outlet location.

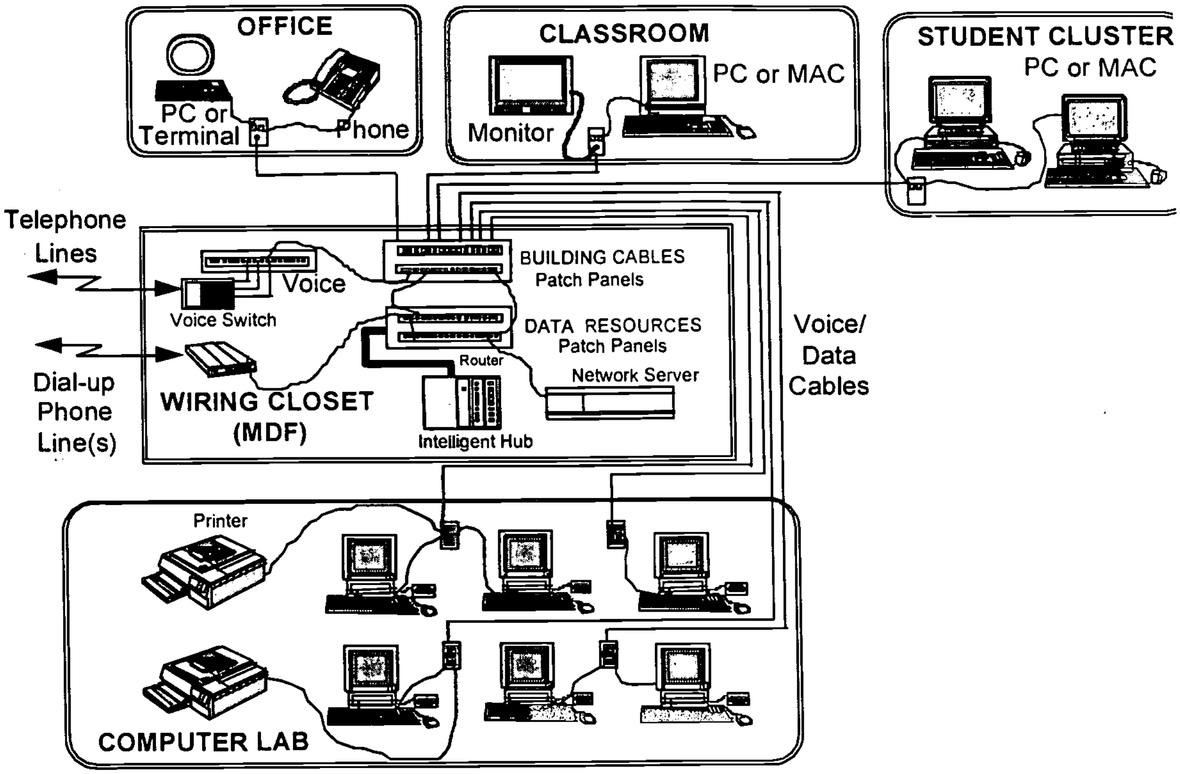

Figure 3-1: Structured Voice/Data Cabling System

3.2.4 Bi-directional CATV—Broadband RF Distribution Cabling System

Video distribution cannot be neglected in building wiring. Current bandwidth capacities of data cabling schemes present problems in meeting video distribution requirements. Therefore, a separate cabling scheme for high bandwidth applications is included in this design.

The most widely employed cabling standard for this type of information distribution is known as broadband radio frequency (broadband RF), which is employed in current cable TV systems throughout the nation. Broadband RF allows multiple programs to broadcast simultaneously. This is in contrast to baseband RF, which allows only a single program to broadcast. Broadband RF is a completely open-standard design that allows competitive bidding for both the installation and certification of the cabling system.

In a bidirectional broadband distribution system, the transmission signal is balanced to allow program generation from any room outlet throughout the building. Ability to generate, as well as distribute, video programming provides the school with additional capabilities, such as teleconferencing and distance learning. It also offers the potential for program distribution to the local cable TV system for townwide distribution of school-generated programs.

The ability to provide a signal-balanced cabling structure allows the distribution of video signals to be bidirectional. This means that any network outlet with a drop cable connection can become a broadcast source for the cable system. The sub-split design provides the ability to operate simultaneously up to seven in-bound or return channels that operate in the cable TV channel assignments T-7 through T-13.

The standard for CATV broadband distribution is based on the arrangement of two cable types. The first of these types, the trunk cable, is usually an RG-11 coaxial cable with very low attenuation ratios. The second type, the drop cable, runs from multitap splitters placed at strategic locations along the trunk cable to the video outlets in rooms. The multitaps provide signal balancing between the trunk and drop cables. Figure 3-2, Bi-directional Broadband Distribution System, provides a pictorial schematic of the broadband RF cable design.

This cable infrastructure design is capable of transmitting in excess of 30 simultaneous programs that range from channel 2 on the VHF standard TV broadcast frequency to the superband RF channel "W," otherwise identified as cable TV channel 35.

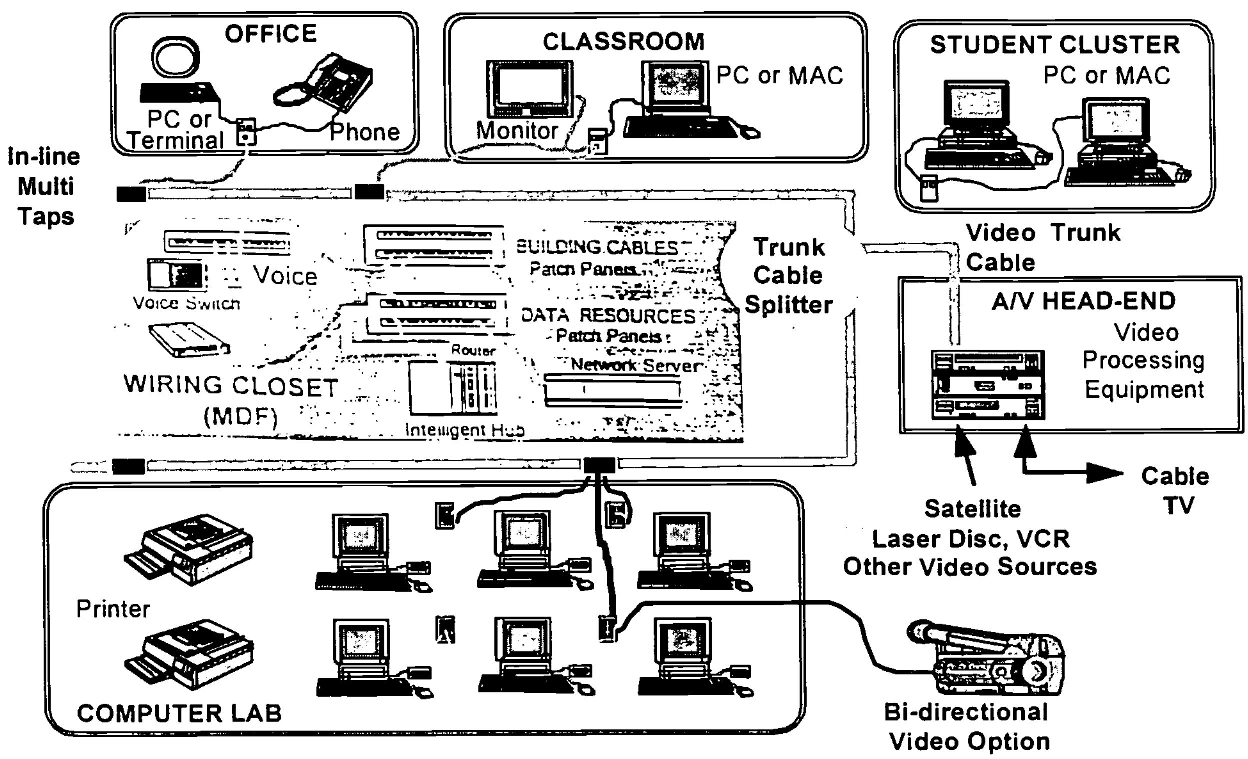

Figure 3-2: Bidirectional Broadband Distribution System

3.2.5 Head-End Requirements

The "head-end" room is the location from which voice, video, data, and other technologies can be centralized to provide a master control center for the school's technology systems. Typically, this area should be located near or within the school's library media center so that it may be easily accessed.

The function of the head-end is to be the information control center of the school. It should be the preferred location for all telecommunication services such as telephone, cable television, Internet, and satellite dish. The head-end can also provide the interconnection of the building communication resources such as clocks, bells, paging, and media access/retrieval systems.

Establishing this central control point also creates the hub from which wide-area or district-area networks can be configured. The layout and design of these networks are not within the scope of this document. However, the design of the technology infrastructure for eventual attachment to a wide-area communications network is included.

This "head-end" room should be at a minimum 8' by 10', larger if possible. Plans for equipment layout and future expansion must be developed. Electrical power supply and ventilation are also important factors as heating loads will vary with the amount of equipment placed in this location.

3.2.6 Distribution Area Requirements (MDF/IDF Areas)

The main distribution frame (MDF) is the primary structured wiring distribution point for the building. In instances where additional cabling distribution points are required, the MDF is the point from which the interconnecting "backbone" cables are originated. When more than one cabling distribution closet or frame is required, the other distribution points are referred to as intermediate distribution frames (IDFs). These structured wiring closets are used to disperse the voice and data communication circuits to the required room outlet, eight-position modular receptacles often referred to as RJ-45 receptacles.

3.2.7 Cross Connect (X-Connect) Area Requirements

In school facilities that incorporate the "integrated technology" approach to technology infrastructure design, the use of "cross-connect closets" represents a means by which the individual cable runs of the clocks, bells, paging, and media access/retrieval systems can be collapsed into multiple pair cables, reducing the number of individual cables running throughout the facility. These closets typically would not require electrical power support, and placement of plywood backboards is normally all that is required in these locations. The placement of punch down blocks on the plywood back boards provides the individual cable to multipair cable transition. The closets can also serve as the cabling riser location as they can be arranged with floor or ceiling core holes (typically 4" diameter and sleeved). These riser locations provide the floor-to-floor transition for technology infrastructure cabling.

3.3 Cable Plant Design Options and Guidelines

3.3.1 Building Layout Categories

The overall size of the building will determine the number of wiring closets or distribution frames that will be required. The cable lengths from a distribution frame must be kept under 90 meters (approximately 290 feet). The more centrally a distribution frame can be located, the more of the facility it can serve. Please note that the data network cable layout governs the building size categorization. The video cable layout is based on cable television layout standards and is capable of accommodating any of the known school-building size configurations.

Small Buildings

Many school buildings are small enough to require only a single distribution frame. The wiring closet would be designated as the main distribution frame (MDF). These buildings would be identified as small buildings.

Intermediate Buildings

School buildings that cannot be cabled from a single distribution frame but can be wired from a second distribution frame in addition to the MDF will be identified as intermediate-sized buildings. The second wiring closet would be designated as the intermediate distribution frame (IDF).

The cabling between the MDF and IDF is known as the backbone cable. Two backbone cables will run from the MDF to the IDF. The fiber-optic cable will provide data infrastructure interconnections between intelligent hubs. A multipair, UTP Level 5 cable will provide the voice communications backbone.

Large Buildings

School buildings that require more than two IDFs in addition to the MDF would be identified as large buildings. In these instances, the IDFs would be located in rooms or wiring closets best suited to cover as many rooms within the 90-meter distance criteria. It's important to note that the cost impact of an additional IDF can be 5 to 10 percent of the infrastructure cabling cost, thus the number of IDFs should be kept to a minimum. The backbone cabling is from the MDF to each of the IDFs (star configuration). The number of backbone cables is a function of the number of IDFs.

Campus-style Buildings

Some schools with multiple buildings on the same property (campus) will require interconnection of the wiring between buildings. In these instances, each building must be analyzed on the basis of the building size configurations above. One building should be identified as the campus center for wiring purposes, and its MDF should be identified as the campus' main distribution frame (CMDF). The cable pathways between buildings should be kept as short as possible to reduce costs. All inter-building cabling must run through a watertight conduit of sufficient diameter to permit doubling the initial quantity of cable running between buildings.

Table 3-1 provides a summary of the minimum building wiring standards appropriate for Connecticut schools.

Table 3-1: Minimum Building Wiring Standards Summary

Infrastructure Area	Component	Data	Voice	Video
Work Area	Connector	RJ-45	RJ-45	F Connector
	Pinning	EIA/TIA 568-A	EIA/TIA 568-A	N/A
	Face Plate	Four (4) Composite		
	Distribution	One per Work Area		
	Mounting	Permanent / Wall Mount		
Horizontal	Cable	Level 5 UTP	Level 5 UTP	RG-6
	Conductor	4-Pair (8 Conductor)	4-Pair (8 Conductor)	1
	Install	Conduit/ Cable Tray/Hidden		
Distribution Frame	Patching Connector	RJ-45	RJ-45	N-Type
	Punch Down	110 Type	110 Type	N/A
	Mounting	Wall/Cabinet		
Backbone	Cable Type	Fiber Optics	Level 5 UTP	RG-11
	Conductor	12 Strand	100 Pair	1
	Connector	ST-Type	Amp 50 pin	N-Type
	Mounting	Conduit/ Cable Tray		
Campus Backbone	Cable Type	Multimode Fiber Optic	Level 5 UTP	RG-11
	Conductor	12 Strand	100 Pair	1
	Connector	ST-Type	Amp 50 pin	N-Type
	Mounting	Conduit/ Overhead Pole /Direct Burial		

3.3.2 Building Cable Layout and Routing

Consideration must be given to the different kinds of walls and ceilings in each room during the technology infrastructure design. Certain building parameters will facilitate the installation of cabling, while other features will impede the process and ultimately increase the installation cost. The following items highlight the areas to be analyzed when considering the installation of data or video cabling systems.

3.3.3 Building Walls, Ceilings, and Floors

Building walls, ceilings, and floors have a great impact on the building wiring options available to installers. The ability to route cables in suspended ceilings or existing conduits can reduce the installation cost significantly compared with facilities that require the addition of conduit or wiremold cabling pathways. State and local fire codes require that buildings built with air-return type ceilings use plenum-rated cable jacketing. This type of cable covering is more expensive than standard PVC jacketing; however, overall costs may be lower when cabling through an air return plenum, since the use of PVC cable in this space would require the installation of sealed conduits.

Ceiling Considerations

The type of existing ceiling will have an impact on the ease and ability to run cabling throughout the school facility. Drop or suspended ceilings allow easy access to the space above a room or hallway so that cable can run without being placed in conduit or wiremolds that would be required if the cable were exposed.

When plastered ceilings are in place, cabling often is much more difficult. In this case there are two options:

- The cables should be placed along the ceiling in wiremold or conduit.
- Access holes should be cut in the ceiling to allow the cable to run above the existing ceiling.

Both options will incur additional expense.

An alternate approach that could be used in older schools where ceiling heights are 9 or 10 feet is to install a lower suspended ceiling that would allow cabling over the new ceiling. This would be a costly approach, but there are other side-benefits to be realized from such alterations:

- Reduced air space results in reduced heating and cooling costs.
- Facility improvements can be funded from sources other than technology budgets.

In some instances, the ceiling may be composed of cellulite tiles that are stapled or attached to ceiling straps. These tiles can be removed if the installer is very careful and replaces the tiles with little visible marring. However, in most cases, the ceiling will show the effect of the tile removal.

An additional ceiling option is the use of air return ceilings, where the space above the ceiling is used as the return plenum for the HVAC system. In these areas, the state and local fire codes require the use of a plenum-rated cable jacket, also known as plenum-rated cable. Plenum rated cable is more expensive than the standard PVC jacked cable.

Wall Considerations

The type of wall that cabling must pass through or be attached to impacts the cost of cabling and the degree of protection of the cable itself. In buildings with sheet rock or plastered walls, normally it is possible to snake wire into the wall and install outlet boxes that mount flush into the wall. In these instances, the wall will act as the cable-routing channel and protect the cable from harm.

In buildings that have concrete or block walls, the ability to run cabling through the wall is nearly impossible. In these instances, the cabling must be run in conduit (3/4") or wiremold to protect the cable from damage. The wiremold or conduit must be secured firmly to the wall surface so that reasonable force will not detach it from the wall.

Fire stopping is another important consideration regarding walls. Whenever a cable or group of cables pass through a fire wall, the hole must be filled with fire retardant materials in accordance with state and local codes.

Floor Considerations

The type of flooring has an impact on building cabling where outlets are identified to be floor mounted or in instances where cable routing between floors is required. In all cases, the structural integrity of the floor must be maintained and all pathways must be fire stopped as required by state and local building codes.

In some instances, the cable will need to run over an existing floor to reach an outlet location in the middle of a room. In these instances the use of suitable floor cable protection is required. Cable bridges are floor cable conduits specifically designed to allow foot traffic over surface mounted floor cabling. Floor attachment is important as the protection of the cabling must be maintained.

Power Pole Considerations

Some cabling locations will not be accessible via any of the previously described methods. In these cases, the use of dual-channel power poles can provide the means to route the cable to the required location. The power poles should be extruded aluminum or ridged steel to ensure adequate strength and resistance to damage.

3.3.4 Cabling Pathway Issues

The routing of both data and video cabling generally is arranged from the appropriate MDF or IDF via the hallway ceilings and into the specific room with network outlets. Cable routing will follow the EIA/TIA 569 Commercial Building Standard for Telecommunications Pathways and Spaces. Table 3-3, Building Wiring Installation Standards, describes the basic guidelines pertaining to the installation of cabling. Table 3-4, Cable Routing EMI Source Spacing Standards, lists guidelines that pertain to safe distances that must be maintained when running UTP near sources of electromagnetic interference (EMI).

Voice and data cabling will run from the room outlet to the MDF or IDF. This cable must be a continuous length with no breaks or sharp bends. It must be supported to prevent undue stress or sagging.

The video trunk cabling will run from the video head-end room through the hallways so that it provides drop cable attachment to cover all required outlet locations.

The backbone cabling, if required, is from the MDF to the IDFs.

Table 3-2: Building Wiring Installation Standards

Location/Phase	Installation Standards
Planning	Wiring installation is to be addressed during building surveys, design reviews, technology planning, and implementation inspections.
Walls, Ceilings, Floors	All wiring should be placed behind walls, above ceilings, or beneath floors. When this is not possible wire runs should be vertical or horizontal only and be placed in conduit, traps, or channels colored to match the wall or ceiling.
Suspended Ceilings	Cabling is not to be laid on top of suspended ceiling panels that may be lifted for access to other equipment. Permanent installation should be secured to ceiling support rods.
Supports	All wire runs are to be supported by permanently attached supports at intervals close enough to ensure no visible sag. All equipment attached to walls must be secured properly.
Fire Walls	All penetrations of fire walls are to be properly and completely sealed with nonflammable material.
Cabling	All cabling will be cut to fit. Excessive lengths of cable between units is unacceptable.

Table 3-3: Cable Routing EMI Source Spacing Standards

EMI Source	Minimum Distance
Fluorescent Lighting	**12 inches**
Neon Lighting	**12 inches**
High-Intensity Cold Cathode Lighting Mercury Vapor, Halogen, etc.	**36 inches**
Audio Microphone Wiring	**12 inches**
Unshielded Power Cable 2 KVA or Less	**5 inches**
Unshielded Power Cable over 2 KVA	**12 inches**
Transformers and Motors	**39 inches**

3.3.5 Electrical Power Availability Issues

In most school buildings, installations, additions, and changes to the power wiring infrastructure are governed by the local town, city, building, or electrical inspector. These governances are generally based on the National Electric Code, but may be more restrictive. The local codes take precedence over both state and federal standards. Where questions over jurisdictions arise, the local electrical/building inspectors office should be contacted for clarification.

4. TECHNOLOGY SYSTEMS

4.1 Voice Systems

For the purpose of this section, discussion will be limited to those areas directly related to voice communications and those capabilities that are supported over voice-grade telephone lines (e.g., low-speed data). Traditionally, schools have treated voice communications as an administrative network used to allow school officials to conduct day-to-day school business. However, with the emergence of tools such as voice messaging and dialup data telecommunication services — along with a growing interest to communicate more often with parents, schools now recognize the need to extend telephone access to teachers and their support staff. This section will provide an overview of basic telephony and highlight areas that should be considered as schools are designed or retrofitted.

Most of today's schools rely upon plain old telephone service (POTS) as the means to provide voice communications to the staff. Single telephone lines are terminated directly to individual locations (typically, the principal, main office, nurse, and possibly the cafeteria or teacher's preparation area). These lines may route traffic through an answering point in the main office or terminate directly to the individual user. For the most part, options such as call forwarding, multiple answering points, or conference arrangements are non-existent in schools of today. In recent years, some classrooms have been equipped with phone outlets to enable students and teachers to use online services and enhance parent-teacher communications. Many of these telephone lines are added to existing telephony arrangements on a piecemeal basis.

As new schools are built, or older ones retrofitted, schools are beginning to develop telecommunications plans that include the needs of teachers, students, administrators, and support staff.

4.1.1 Telephone Networks

Public switched telephone network is owned and operated by the local phone company that provides the capability to make telephone calls from one location to another. The public switched network is comprised of a number of different companies, including those that provide local service and those that provide long-distance capabilities.

Customer premise network serves a local building or buildings and is maintained and operated by an individual business, school, or customer. This network is comprised of wiring and equipment which interfaces with the public network described above.

4.1.2 Service Options

There are essentially three types of telephone services that can be used in a school:

Plain old telephone service (POTS) -- With this system, single lines terminate directly to end-user telephones. The service is usually used to describe residential service where a single line serves one household.

Private branch exchange (PBX) -- With this type of service, a telephone switch is located on a customer's premise and interfaces with the public switched network.

Central office-based services (Centrex) -- With this system, a local telephone company provides a set of services that enables customers to use the telephone company's switching equipment to provide room-to-room calling as well as an interface to the public switched network.

Table 4-1 compares and contrasts features of the above systems.

Table 4-1: Comparison of Service Options

Service	External Call Capability	3-, 4-, or 5-Digit Internal Call	Intercom	Bells	Maintenance Responsibility	Dialup for Modem Telecom
POTS	YES	NO	NO	NO	Telephone Company	YES
PBX	Limited to number of external phone lines	YES	YES	Option	Equipment Provider	YES
CENTREX	Limited by contracted service level	YES	YES	NO	Telephone Company	YES

It should be noted that a back-up strategy should be planned in case of power outages.

4.2 Data Systems

Computers and networking have emerged as essential tools in the learning process. Recognizing the importance of these tools, i t is recommended that the following be available to each classroom, student, and teacher.

4.2.1 Data Services

Computer Systems

Regardless of the platform (MS-DOS, Macintosh, etc.), classroom systems should be high-speed color display networks where possible to provide access to information sources outside the classroom. Where networks are not possible or feasible, standalone machines with modems are desirable.

Electronic Mail

Electronic mail or e-mail is a means of removing two of the greatest barriers to communication: distance and time. E-mail is similar to voice mail in that a message is recorded and stored electronically. E-mail can be sent over phone lines or open forums in commercial services such as CompuServe, America

Online, Prodigy, or the Internet. E-mail can also be sent between computers on a local network.

Electronic Bulletin Board and Conferencing Systems

Electronic bulletin board systems (BBS) and conferencing systems provide structured communications to multiple people. BBSs provide relatively static information, such as school policy or the week's school lunch. Often implemented by a standalone computer with multiple modems, these systems are currently being replaced by World Wide Web (WWW) computers able to handle graphics as well as text.

Conferencing allows people to create topics around which multiple people can respond with comments or questions. Unlike e-mail, everyone can see both the original message and all responses.

Facsimile (fax) Machines

Facsimile (fax) machines can be used to transmit documents or images over long distances via telephone lines. Faxes can be standalone, built into computers for modem or BBS transmission, and can be available as a shared resource in local-area networks.

Recently, the advent of combined services equipment has enabled sites to reduce the number of individual pieces of hardware that they need. For example, it is possible to obtain a fax, optical character recognition (OCR) scanner, laser printer, and modem all as part of one piece of equipment.

4.2.2 Electronic Networks

Local-Area Networks

Local-area networks consist of multiple computer units tied together by high-speed connections. While dialup systems serve to cover large areas at relatively low speeds, local-area networks (LANs) connect limited areas, usually one room or building ring, at very high speeds. There are multiple technologies that can be used such as, Token Ring (Institute of Electrical and Electronic Engineers (IEEE) 802.5), Ethernet (IEEE 802.3), and Fiber Data Distribution Interface (IEEE 802.12). These operate in the 10 to 100 megabytes per second range. The LANs provide shared access to limited resources such as pooled modems, high-speed printers, and shared access to software, data files, and graphical images.

Wide-Area Networks

Wide-area networks (WANs) are a hybrid technology used to interconnect local-area networks (LANs) or allow network interconnections between points normally beyond the generally accepted network distance limitations. Dedicated high -speed communications over phone lines via networked modems are the most common WAN arrangement. The use of line-of-sight or similar broadcast technology and dedicated high-speed routers over specialized media such as fiber optic lines are alternative connection strategies. WANs are more frequently being used in districts as a way to interconnect the LANs in each of their buildings and to connect to the Internet.

National Information Infrastructure - NII

The emergence of the National Information Infrastructure (NII) as delineated by the Clinton administration in 1994 has highlighted the importance of interconnecting local networks with other networks across the state, nation, and the world.

Presently, the "Information Superhighway" or Internet consists of over 30,000 computer networks which comprise over 2,000,000 individual computers and allow some 20,000,000 or more individuals to send information between and amongst each other in the form of electronic mail, and to retrieve stored documentation about a wide array of topics.

4.3 Video Systems

Today, the traditional lines between television (video), computers, audio, print, and film-based instructional materials are disappearing and the traditional formats are merging into one. Ready access to video-based instructional materials is essential to provide Connecticut students with a "world-class education."

All instructional areas of the school must be part of a structured cabling system capable of supporting reception and transmission of video and audio programming. Sufficient flexibility must be included in the design of the cabling system to allow for the inevitable changes in room function.

4.3.1 Utilization of Video-Based Instructional Programming

Each instructional area should be capable of fully participating in video-based instructional programming. The following minimum guidelines apply:

Multiple program access -- Sources would include local origination; cable television (CATV) received via cable drop to the school; master antenna television (MATV) received via a rooftop ; instructional television fixed service (ITFS); microwave signals received on a line-of- sight basis using a special antenna and decoder; satellite (downlink of programming using a C and/or KU-band satellite dish); VCR; laserdisc; computer; CD-ROM; video file server; classroom programming ; and school - or district-wide programming.

Teacher control -- Each teacher, from the classroom should be able to control the technology devices power on/off, program selection, volume, and lighting.

Security -- The school facility must be capable of safeguarding system equipment, file server information, and program access.

Video image(s) -- Display devices must be sized to serve the entire class. This includes devices such as large screen TV/monitors, video projection, and other necessary adaptive technology for students with special needs.

System compatibility -- Video displays must be data compatible.

4.3.2 Single Camera Video Generation

All instructional and administrative areas should support live video program generation. This includes the ability to connect a single camera to the video infrastructure by means of the radio frequency (RF) video receptacle and distribute the camera's image throughout the building.

4.3.3 Video Production

Video production facilities must be designed to meet current needs with provision for expansion. Consideration must be given to providing an area where acoustics, light, climate, AC power, security, and outside access can be controlled.

A video production facility must make provision for:

- broadcast over building network, outside the building
- receiving from the building network, CATV, MATV, ITFS and both C- and KU-Band satellite
- integration of:
  - graphics from print materials, three-dimensional objects and computer generation
  - video cassette
  - laserdisc
  - CD-ROM
  - film (either still or motion)
  - audio from microphones, recordings, radio, or other video sources
- post production facilities for:
  - editing
  - previewing
  - preparation of materials
  - instruction

4.3.4 Distance Learning

Any instructional area to be used for distance learning must have access through the building network to the external distribution and reception systems to be used for distance learning. Design of the building network must take into consideration the various external systems that are currently available and those available in the future. Among the systems to be considered are: satellite, microwave, cable television, private network, and switched public network. Each of these systems may use one or more technologies such as digital signal on fiber, compressed video or analog video on fiber.

4.3.5 Administrative Use of Video

The administrative use of video is just beginning to come into its own. In addition to the obvious benefits of its use for professional development and staff training, the benefits to student, staff, and facility security have barely been addressed. The potential in the use of video for security should be taken into consideration in the overall design of the building network, AC power distribution, and lighting.

4.4 Integrated Technology Systems

The consideration of "integrated technology" is becoming more and more attractive an option for schools to consider as a means of coordinating the many levels of building communications. What separates "integrated technology" from the conventional approach to technology infrastructures is the inclusion of the bell, clock, paging, and media access/retrieval systems. These systems introduce various means of providing building communications for school use. Control of these systems can, typically, be accessed by way of electronic PBXs that allow handset dial tone modulated frequencies (DTMF) to be directed to the appropriate technology system to activate or deactivate its functions.

5. TECHNOLOGY GUIDELINES FOR SPECIFIC SCHOOL AREAS

The movement from curriculum-specific classrooms to cross-curricula environments is one of the education reform issues that many educators are currently assessing. Recommendations are made to develop a customized classroom layout for each curricula r environment. Recommendations pertaining to alternate room groupings or utilization strategies must be forwarded to the Department of Education for consideration.

Appendix C contains sample facility layouts. A room-by-room consideration will allow the charting of each building area and the assigned technology access requirements. This information is important in providing a cost estimate for both the infrastructure (cabling plant, distribution closet equipment, bidirectional video system, voice switching equipment, telephone handsets, data hubs or backbone cables) and eventual technology components (computers, file servers, software or A/V equipment).

5.1 General Classroom Technology Infrastructure Guidelines

The classroom is the core of the educational facility. Flexible accommodations for technology resource access should remain paramount in locating outlets and placing technology components. Various areas should be considered.

5.1.1 Teacher Work/Presentation Area

Establishing a teacher's work/presentation area allows one access location to serve two purposes:

- teacher communication with administrative and educational resources for more efficient flow of information
- presentation of information to an entire class

Typically there are three approaches that can be employed for a whole class display system: large screen TV/monitor, LCD panel projection via overhead projector, or data projectors.

5.1.2 Student Access/Workgroup Area

Groups or teams of students collaboratively work on projects or tasks assigned by the classroom teacher. To assist the process of team work, the provision for student access to voice, video, or data resources is necessary. In elementary levels of education, the use of student workstations provides a means by which small groups of students can access the school's informational resources while the teacher presents to the rest of the class. For this reason, the student access/workgroup area should be placed where it will not distract students who are not working with the computers.

Typically, student work areas should be planned to accommodate two to six workstations. Refer to section 6.2.2 for student workstation requirements. In situations where special needs or assistive technologies must be accommodated, Americans With Disabilities Act (ADA) guidelines must be followed.

5.1.3 Other Classroom Considerations

The location of printers, the storage of programs, software, printing paper, blank disks, copies of various programs for student use, and other miscellaneous supplies must be planned. Provision for secured storage must also be planned. Either free standing or built-in units should be considered.

Whiteboards should be the standard in classrooms where technology is used.

All students and teachers should have access to video cameras, stereo VCRs, a large viewing projection screen, and multimedia equipment as needed.

The electrical power needs of the classroom will increase as the number of workstations increase. Even with the development of laptop portable computers, the need to provide electrical power is essential as battery technology will not accommodate the students' needs for whole class period access to the workstations. The standards for electrical power requirements are discussed in Part B, "Facility Options and Recommendations."

5.1.4 Science Classroom

The science classroom may need to become an exception to the general classroom design rule in order to accommodate the needs of a science-oriented curriculum. This would include the arrangement of a technology access point located on the central demonstration table, as well as a provision for student workstation access at the student demonstration tables (typically 2 to 4 outlets per table).

5.1.5 Small Group Classroom

Small group classrooms normally do not allow enough space for a teacher presentation area. However, student workgroup access is required. Teacher access to the system can be provided via a student workstation or provided by means of a standard technology outlet that accommodates the teacher workstation without the overhead video presentation equipment and wall outlets. Alternatively, wall-mounted video displays can be downsized to the appropriate level for the room size (i.e., 13" to 21" TV/ Monitors). If this alternative approach is selected, then a full teacher work/presentation area needs to be planned.

5.1.6 Art Classroom

The art classroom presents a need to anticipate the location of equipment not normally planned for the general classroom. This equipment includes devices such as scanners, multiple printers, multimedia rich workstations (i.e., full-motion video and audio capability), and at least one large screen with high-resolution color.

5.1.7 Music Classroom

The music classroom presents an area that needs special equipment. Locations for the placement of multiple electronic, MIDI-compatible keyboards with headsets, sound recording and editing equipment, and other audio-visual equipment (e.g. , VCRs, CD-ROM players, and high-fidelity loud speakers) need to be planned.

Every room in which music is taught should be equipped with a high-quality sound reproduction system capable of recording and playback using current technology (i.e., cassette recording tape, digital audio tape). Students should be able to operate at least some audio equipment.

Every music teacher should have convenient access to durable sound recordings representing a wide variety of musical styles and cultures (i.e., compact discs or CD-ROM s.)

In every school, the following should be available for use in music instruction:

- multiple microcomputer workstations, each of which includes a color monitor, MIDI interface, synthesizer, microphone, stereo headphones, speakers, CD-ROM drive, connection to a printer, and appropriate music software
- multiple electronic, MIDI-compatible keyboards with headphones
- music-related CD-ROM s

5.1.8 Technology Education

The technology education classroom/laboratory presents an area that needs to be arranged with special equipment. The basic classroom configuration requires much the same as a general computer lab. For example, the classroom/lab may house a communication lab and require multiple workstations for accessing telecommunications, building networks, desktop publishing, computer-assisted design, video production and input access to local cable service providers. In a manufacturing or research and design lab, access to desktop CAD/CAM and computer-controlled robot and controllers will be required. In all cases, the presentation area of the classroom should be the same as that described in the classroom section of this document.

The workstation configurations will vary depending on the specific application, portability, and flexibility essential to the delivery of content. In order to provide flexibility, all labs should be designed with the capability to allow virtual teaming between rooms, schools, and outside educational facilities.

The traditional electrical and pneumatic technologies need to be provided consistent with design/modeling labs found in the industry. These devices are prone to creating airborne particulate, thus air filtration capability is essential.

5.2 Library Media Center Infrastructure Guidelines

The library media center represents the general access point for technical resources in the school for both students and teachers. Adequate space for the management of the library media program, the instruction of students and staff, and storage of materials and equipment are outlined in *A Guide to Program Development: Learning Resources and Technology*, a publication of the Connecticut State Department of Education. Incorporating electronic technology into these spaces not only enhances the services to students and staff by delivering information in an efficient and timely manner, but it also improves patron's skills in the successful use of technology. When planning this room, schools must be aware that the area will change dramatically in function and role over time.

5.2.1 Circulation Area

The circulation desk is the area where the library media resources are checked out and returned by students and teachers. A computerized circulation system with bar code scanning should be provided. Network access must be planned and should include outlet connections for at least one workstation with a printer and bar code scanner. Provision for voice communications should also be planned. This typically is covered by a standard administrative office type outlet (refer to Appendix C, "Sample Facility Layouts"). As with all technology outlets, provision for electrical power is essential.

5.2.2 Electronic Catalog Access Area

The arrangement for electronic catalog access is important in providing the advanced means to locate information available within the library media center as well as any outside resources that may be available. The information needs to be a network resource and available throughout the entire facility. The location and identification of the number of workstations available for student use is necessary so that the cabling paths and quantity of cables can be planned. Provision for accessing the card catalog from outside the school also should be considered.

5.2.3 Multimedia Workstations

The availability of computer/multimedia workstations for ad-hoc student and teacher use should be available in the library media center. The number of workstations will depend on available space and local preference. The cabling for these workstations should be arranged to allow additions as more workstations become desirable. The main concern becomes location and furniture type. Planning for the maximum workstation configuration from the start is important so that voice, video, data, and electrical power cabling paths can be identified, since it generally is cheaper to install cable once.

The furniture for multimedia workstations can be very diverse. Both architects and computer furniture professionals should be consulted on the arrangement of this area. The technology cabling and electrical power support must be concurrently planned.

5.2.4 Office Area

The library media specialist's office can be arranged as a standard administrative office.

The technology "head-end" room represents the central location from which voice, video, data , and other technologies can be distributed throughout the school, creating a master control center for the school's technology systems. Typically , this area should be located near or within the schools library media center so that it is easily accessed.

5.3 Computer Lab Infrastructure Guidelines

The computer lab represents a whole-class learning environment with a workstation for each student. If space or workstations are in short supply, no more than two students should be assigned to a workstation. This results in a need to cable the typical computer lab for anywhere from 15 to 30 workstations and to make provisions for four to six printers.

5.3.1 Computer Lab Teacher Presentation Area

The teacher work/presentation area should be the same as that described in the classroom section.

5.3.2 Student Workstation Areas

The furniture for these work areas can be very diverse. Architectural and computer furniture professionals should be consulted on the arrangement of this area. The technology cabling as well as electrical power support must be concurrently planned.

5.4 Teacher Work Area Infrastructure Guidelines

The designated "teacher work areas" are typically either dedicated teacher preparation rooms or a "teacher lounge/work area" combination. In either case the need to provide teachers with technology access outside the classroom is imperative. The need to develop new lesson plans and instructional materials requires that teachers have many more resources available to them than in prior years.

5.4.1 Teacher Preparation Rooms

The teacher preparation room in general is an adult version of the student workgroup area. The requirement is for multiple workstations with adequate space for reference and lesson preparation materials as well as access to resources both inside and outside the school. The number of workstations with access to high-speed copier/printers must be determined by the space available and the number of teachers using the area. Typically , these workrooms are arranged with 4 to 8 workstations with voice, video and data. Telephones and video display monitors should be arranged in these areas .

5.4.2 Teacher Lounge/Work Areas

Because this space serves a dual function, it must meet the requirements of the teacher work area described above and also provide a location where teachers can take a break from the class environment. Typically, the space available for teacher workstations is limited, ranging from 2 to 6.

5.5 Administrative Office Area Infrastructure Guidelines

The administrative offices and work areas represent the control center of the school facility. Incorporation of technology network resources in this area is critical. A floor plan for desks and workstation tables will assist in:

- planning for data network outlet location
- defining the number and type of network outlets required

The outlet type designated for administrative use is a wall plate with two data/voice modular (RJ-45) eight-position receptacles. Provision for video services should also be provided in these areas. This may require adding the video receptacle to an administrative wall plate or locating a video-only location.

Administrative offices such as the principal's or superintendent's, should include voice, video, and data. They employ the type of wall plate referred to as a technology outlet. These outlets consist of two, data/voice modular (RJ-45) eight-position receptacles, an RF video system - BNC or F-connector receptacle, and an optional (integrated technology) video-all-call four-position modular (RJ-11) receptacle.

5.5.1 General Office

The general office area needs to service the secretarial and support personnel that work in the area. At the least, administrative type wall plates and their associated electrical power support should be provided for each work area. Additionally, provisions need to be made for printers, fax machines, or other electronic equipment.

5.5.2 Principal/Vice Principal's Office

These offices should be arranged with full technology type outlets located near the principal's workstation. Optionally, these offices may include a wall-mounted TV/monitor to enable the principal to review building-wide video distribution services and to provide the network access for teleconferencing and video announcements.

5.5.3 Other Administrative Offices

The other administrative offices should be arranged with the conventional administrative-type wall plates located to match the planned workstation placement.

5.6 School Services Area Guidelines

Many times the service areas of the school facilities are not included in infrastructure plans because they don't provide instructional services. However, these rooms should be integrated into the administrative information system.

5.6.1 Guidance Office Areas

Guidance office areas can be arranged as standard administrative offices with the administrative -type outlets or they may be arranged with technology outlets. The technology outlets consist of two data/voice modular (RJ-45) eight-position receptacles, an RF video system - BNC receptacle, and an optional (integrated technology) video-all-call modular (RJ-11) four-position receptacle.

5.6.2 Nurse, Maintenance, Food Services, and Receiving Area Offices

These areas should be equipped with voice, video, and data wall plates.

5.7 Non-Curricular Area Guidelines

5.7.1 Auditoriums

The auditorium/stage area represents a whole-school presentation area. The ability to present information to a large group is particularly important. For this reason, technology tools such as video projection systems and large screen displays are required. The fixed mounting of these devices is recommended to eliminate setup time for each presentation. If these devices are planned and the locations are identified, both data and video cabling can be arranged. Multiple video -only outlets should be located throughout the auditorium to provide single camera connection for videotaping o r live video distribution of events that occur in the auditorium.

5.7.2 Gymnasiums

The arrangement for video drop cabling in the gymnasium and other sports-related areas is recommended to enable videotaping for providing live broadcasting of events held in these areas. Planning for multiple video drops provides greater options for camera angle coverage.

5.7.3 Cafeteria/Cafetoriums

The cafeteria areas represent general student body congregation areas. These areas are well-suited for the display of school notices and other school activity information. If these areas are cabled for data and video drops, electronic bulletin boards, pertinent video programming, and news events can be provided.

5.7.4 Lobby Areas

The lobby areas represent general congregation areas that are well-suited for the display of school notices and other school activity information. If these areas are cabled for data and video drops, electronic bulletin boards, pertinent video programming, and news events can be provided.

5.7.5 Hallways

Hallways are areas where the bell, paging, and clock systems used to control class changes, emergency announcements and general building-wide voice announcements. Normally, only infrastructures that incorporate the

"integrated technology" design would address technology cabling of the hallway areas.

6. IMPACT ON SCHOOL FACILITY DESIGN

When installing a technology wiring infrastructure, it is recommended that the entire facility be wired to the same standards. Existing cable plants need to be evaluated to ensure their compliance with the facility design guidelines described in this document.

The technology wiring standards for both new and existing buildings should be the same. A single set of design criteria simplifies the application of a common wire infrastructure throughout existing or new construction. Additionally, all cables should be installed and tested under the same guidelines.

6.1 Existing Schools

The introduction of technology infrastructures into existing school facilities impacts systems such as electrical and HVAC. Additionally, spaces must be identified for wiring closets, distribution frames, the network head-end room, and workstation locations.

6.1.1 Renovation

Renovation of existing facilities to accommodate technology infrastructures begins with review of the existing facility physical layout and spatial accommodations for the technology-specific areas of the building.

The school should utilize existing furniture (e.g., tables for computer workstations, rolling carts for video monitors, and surplus furniture) whenever possible, resulting in cost savings over the purchase of new furniture. It may be possible to use, alter, or reconfigure existing furniture to accommodate the requirements of new technology devices.

6.1.2 Electrical Update Requirements

Existing buildings require the same technology electrical power as new buildings . Electrical services to existing schools may have to be increased even if the school is not being enlarged. The location and power circuit rating of each electrical outlet must be identified and recorded. Areas such as computer labs and other concentrated computer rooms must be reviewed by a professional to determine the safest and most cost-effective means to meet the electrical power supply needs of each technology area.

6.1.3 Room Lighting

The quantity and quality of lighting should be appropriate to the task at hand and should not exceed that of classroom lighting (30-70 foot candles) to reduce screen reflections. Other lighting concerns include:

- Provide low-level ambient illumination, combined with task lighting, for proper illumination on printed materials used in conjunction with computer, where appropriate.

- Ambient lighting levels for office areas range from 50-to-70 foot candles (fc) or 750 -1000 lux, drawing 1.5 watts per square foot or less. Federal standards suggest using not more than 1.5 watts per square foot as the limit for government facilities with large office needs.
- For energy conservation purposes, fluorescent lighting using a four-tube fixture with a low-noise ballast is preferred over incandescent. Use cool white bulbs with greater than 3,000 degrees Kelvin rating.
- Directional grating and plastic diffusers are recommended to reduce glare. Dimmer controls are helpful.
- Window s require shades, blinds , or draperies to allow the blocking of direct sunlight when necessary.

6.1.4 Building and Equipment Security

Security is necessary to ensure that confidential information is protected from unauthorized personnel. There are two basic types of security:

- physical security
- logical, or network, security

Physical security prevents physical access to system devices or prevents their removal by unauthorized personnel. Logical, or network, security prevents unauthorized access over a network to data programs or other information deemed important over a network. Increasing the level and scope of security increases system costs.

Trade-offs exist between ease of use and security. Increasing security makes a system more difficult to use because it introduces a series of barriers that authorized users must navigate to reach the information they need.

6.2 New Schools

Students must begin learning and using technology skills at the early elementary level so that they can apply those skills throughout their academic years. There must be continuity of access to computers and other technologies at all grade levels.

For electrical services it is recommended that three or more (two minimum) separate circuits be provided to each teaching area. Electrical surge protection should be provided at service to the building or at the electrical panel serving the computers, and electrical equipment must be properly sized for the possibility of high neutral currents to prevent overload.

Air conditioning is being built into parts of many new schools today, not for the comfort of occupants, but to protect the investment in technology equipment , and to provide for year-round use of the building. Lighting has become more energy efficient, and various types of direct, indirect , and specially designed diffusers provide more options for computer-compatible design in a low-energy package. Security is important for building and contents as well as occupants, and the new systems include door contacts, motion sensors and glass breakage monitors.

Integrated communications systems through media networks provide not only for voice, video , and data distribution, but also for announcement, clock, and alarm system ties to the telephone system. This helps to accomplish integration of distance learning as well as satellite and cable distribution to provide a variety of programs to the classroom and between classrooms. It is important that , with the addition of wiring and computers, the training of users be built into technology budgets. It is recommended that 20 cents of every dollar invested in technology be spent on training.

More and more schools are applying for technology to be included in construction projects, and state reimbursement funding is available for new construction or major renovation projects. Please contact the School Facilities Unit of the State Department of Education at (860) 566-1213 for information or documents pertaining to the process for application and review of eligible projects.

6.2.1 Design and Construction Options

The physical layout and construction options that are typically addressed by school facility architects need to incorporate the design factors that facilitate technology infrastructure design and installation. These factors include building layout, ceiling type, wall construction, space allocation for wiring and technology control areas, ventilation, electrical power supply and location, room layouts and physical security, just to name a few.

6.2.2 Space Allocation

Some schools already have space problems resulting in overcrowded classrooms and too few specialty areas. The addition of technology devices presents a location problem that must be addressed. Even in schools where space had not been a problem before, the addition of classroom technology devices such as computers and video monitors will require a re-evaluation of available space.

Spatial guidelines available from the Schools Facilities Unit, State Department of Education, can assist schools in planning for the placement of technology devices within specific rooms of the school building. The guidelines should be planned to cover classroom, computer lab, science lab, special education, administrative, and non-academic areas of the building.

New building construction offers an opportunity to review the spatial concerns that technology devices create and incorporate them into a building design that integrates the application of technology into the process of education.

The application of spatial guidelines for existing buildings is a much more difficult task because each school is arranged differently. Guidelines should be generic and allow for a range of building configurations. These guidelines may describe more variations than might be practical. The consideration of basic furniture space needs might be more appropriate than describing detailed furniture location and space criteria. (See Table 6-1 and Figure 6-1 below.)

Table 6-1: Recommended Computer Workstation Area Size

Usage Type	Surface Area	Storage Space
Student - Grades K-5	30" width x 30" depth	Shelf or drawer
Student - Grades 6-12	36" width x 30" depth	Shelf 36" wide x 12"-14" deep below or to side
Adult	36" width x 30" depth	1.5 linear feet storage, drawer for personal items

As a general rule of thumb, plan on approximately 29 square feet per workstation . This figure includes provision for storage and circulation. The workstation module shown in Figure 6-1 requires 15 to 18 square feet without provision for storage and circulation.

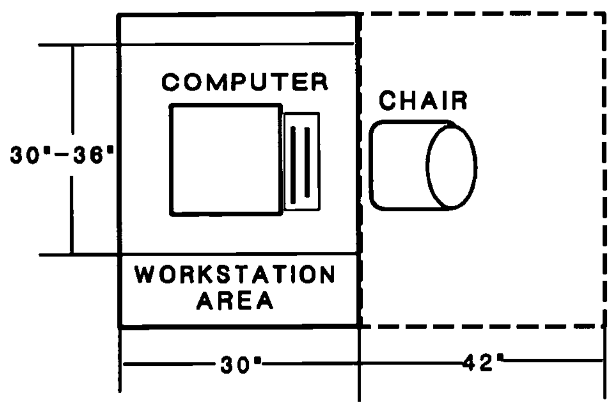

Figure 6-1: Workstation Space Requirements

6.2.3 Acoustics

Noise is measured according to loudness and tone. Loudness, also referred to as sound, is pressure and is measured in decibels (dB). The human ear does not respond to true sound pressure; hence, decibels are weighted to measure sound pressure as we hear it (dBA). Tone, referred to as frequency, is measured in cycles per second (Hertz or Hz). Noise can be controlled by reduction at the source and by the use of sound absorbing materials and treatments.

It is desirable to include in the specifications acceptable noise levels for specific activity areas. Acceptable noise levels for large office areas (40-50 dBA) may serve as a reference point.

Computer-generated noise can be minimized through the purchase of equipment without fans. Hard drives are another source of noise. Units should be purchased that produce a minimum level of noise.

Computer-generated noise may be a sufficient reason to consider acoustic treatment beyond simple acoustic lay-in ceiling tiles. Computer labs, business education classrooms, and other areas housing several computers will benefit from wall coverings such as acoustic panels with a .90 noise coefficient and glued-in acoustical ceiling tiles. The ambient noise level should be maintained at less than 45 dB SPL, A weighted.

Uncontrollable exterior noise can be reduced significantly by a large mass of material in the exterior walls. Sealed, double-glazed windows help to reduce exterior noise. HVAC-generated noise can be reduced by placing fans in remote locations, mounting equipment on vibration-reducing pads, and in general, by not placing HVAC equipment directly over instructional areas. Air turbulence in ducts may be reduced by proper design.

The human ear filters out most interior noise; microphones do not. Therefore it is important to consider proper acoustics when establishing a broadcast area such as a two-way interactive TV classroom or television studio.

6.2.4 Planning for Future Expansion

Whenever possible, planning for future expansion of technology throughout the school facility should be considered including:

- classroom alteration to allow more student workstations
- ability to increase the circuit capacity of the distribution frame and wiring closets
- provisions for extra power circuits, and accommodation to new or emerging technologies such as teleconferencing and distance learning rooms

Adherence to these considerations will facilitate any necessary upgrades.

GUIDELINES FOR TECHNOLOGY INFRASTRUCTURE IN CONNECTICUT SCHOOLS

Part B:

Facility Options and Recommendations

7. INTRODUCTION

7.1 Overview of School Facilities

The physical aspect of educational technology represents a major investment that must be accomplished as cost effectively as possible. Careful consideration should be given to each of the many issues and requirements that affect a building and/or its technology infrastructure. The following sections describe the various areas, aspects, and options that should be considered for inclusion as design recommendations .

7.2 Standards and Utility Issues

7.2.1 Communication(s) Utilities

This document addresses the infrastructure, wiring, and equipment used to distribute media *within* the school building. Voice (telephone), video, and data exchange external to the school building will make use of an appropriate telecommunications utility as carrier and is not addressed in this document.

7.2.2 Electrical Power Utilities

Typically, electrical power is supplied to the school building by a local power company as directed by the Department of Public Utilities Control (DPUC). Within the school building, the further supply and distribution of electrical power is governed by local city or town building codes, subject to inspection and/or license.

7.2.3 Spatial Standards

The Connecticut State Department of Education has established guidelines regarding room square footage with respect to new construction of classrooms and other school building areas. These requirements do not apply to older, existing buildings that pre-date the standards.

7.2.4 Heating, Ventilation, and Air Conditioning (HVAC) Standards

HVAC takes on greater meaning as technology devices are added to school environments as they:

- produce more heat and increase ambient temperature
- are frequently sensitive to humidity
- are affected by pollutants in the air

Students, staff, and equipment can be adversely affected by high temperature and humidity. Adequate ventilation and air conditioning are strongly recommended for technology networking installations and are reimbursable in school construction projects.

7.2.5 Environmental/Ergonomic Standards

A number of building environmental factors must be considered in regard to utilization of technology devices in a school building. These factors, known as "ergonomics," address issues such as lighting, monitor screen emissions and glare, noise and acoustics, electromagnetic radiation levels, and equipment positioning.

Few widely recognized standards exist in this area. As a result, specific concerns impacting implementation will be addressed in section 4.4. These concerns have not been categorized formally into a standards format but the implementation section will suggest basic guidelines in these areas. The Americans with Disabilities Act (ADA) guidelines must be followed.

7.3 Evolving Facility Technologies

7.3.1 Wire-based Technologies

The phrases "building-level network" and "local-area network" as used herein refer to that computer technology network housed within a given school facility or building. They do not include similar networks housed in other buildings of the same campus, nor any other external network with which they may or may not communicate.

The speed of building -level networks is rising from the medium-speed networks of Ethernet (10 megabits per second [Mbps]) and Token Ring (16 Mbps) to 100 Mbps and above.

Standards, such as the fiber data distributed interface (FDDI), provide speeds of 100 Mbps but use techniques and framing different from Ethernet and Token Ring. Recent standards (principally 100BaseTX and 100 VG-Any LAN) are designed to achieve the higher speeds and still maintain significant compatibility with installed networks. The wiring infrastructure must support both the medium- and high-speed network standards.

Newer standards, such as FDDI II and asynchronous transfer mode (ATM) address the transport of time-sensitive voice and video data, where delays can cause voices to halt and pictures to be jerky. Of the two, ATM holds the greatest potential since it can be deployed throughout the network -- from the wiring closet to the local telephone company to long distance carriers -- and can operate at much higher speeds. It can operate over unshielded copper wire at low speeds and over fiber at higher speeds (155 Mbps and up). Efforts are underway to get ATM to operate over copper wire at 155 Mbps. ATM will probably first be used widely as the backplane of network hubs and for connecting hubs together in large buildings. In summary, when designing technology infrastructure, consideration should be given to future needs as well as current standards.

7.3.2 Wireless Technologies

Laptop computers may be the basis for "wireless" links in many local-area networks. They can provide a means for visitor involvement in classroom activity, non-rigid access within libraries, or other access where all fixed workspace units are in use. "Wireless" networks still require a wired backbone throughout the system.

Because of present limitations in range and speed of operation, wireless access units must function as a bridge between the backbone network and a roaming user. The future success of wireless technology may depend on improved battery capacity and declining costs. Present technology suggests that hard wired units offer greater efficiency in speed of operation and bandwidth capability.

Existing wireless telephone and data communication systems are useful for temporary use, such as might be the case within a gymnasium or other space that might be used for activities requiring communication services to a number of locations not on a permanent basis. Extensions of service to small or remote buildings might be provided more economically via wireless products, and this can be reviewed on a case-by-case basis.

8. CRITERIA

Many ways exist to accomplish a desired outcome. It is important to state explicitly the design criteria which guide the selection of the recommended approaches. This section describes those criteria and their importance.

8.1 Types of Standards to Be Considered

Technology standards are essential in the current information revolution. Standards allow components purchased over space and time to work together and ensure safety to people and property. Complex systems require standards. The four basic types of standards follow:

- **De-jure standards** are required by law.
- **Open system standards** are maintained by an open, public consensus process to accommodate new technology over time.
- **De facto standards** are products with significant market share that are widely supported by many different vendors.
- **Proprietary standards** are often protected by patent or copyright established by a vendor, and usually not licensed to other vendors.

The infrastructure must be consistent with de-jure standards, but have flexibility in adopting other standards. Use of open and de facto standards, rather than proprietary standards, improves the inter-operability and functionality, minimizes purchase costs, protects investments in hardware and software, reduces training costs, and lowers support costs, while speeding problem resolution.

Open system standards should be implemented to the greatest extent possible. When this is not possible, de facto standards should implemented. Only as a last resort should the design be based on proprietary standards.

8.2 Flexibility

The infrastructure should incorporate components that can perform several different functions whenever possible. Such flexibility means that components purchased for one purpose can be redeployed for another purpose should curriculum or administrative needs change in the coming years.

Flexibility lowers the overall cost of the system and protects investments in the face of changing needs.

8.3 Expandability

Significant amounts of technology are being introduced into schools. Components purchased and installed initially must be designed and selected to meet future needs. Schools need to purchase equipment that can be added to or expanded to support future demands. This strategy ensures that schools do not buy capacity today that they do not yet need; at the same time, it protects today's investments by ensuring their usefulness in the future.

Expandability can be addressed in several ways. One approach is to ensure that enough extra memory, processor speed, disk space, etc., can be added to meet future anticipated demands. This implies that systems that are near their maximum capacity should never be purchased. All important design features should be able to be increased above the level of system purchased.

A second way to provide subsystem expandability is to join multiple systems together, but appear to function as a single unit. For example, a second file server could be placed in the school and tied to the first, so that a single user log-in could provide access to both servers.

Good expandability lengthens the product life cycle of a component, lowers overall cost, and ensures that capacity can be purchased as needed to meet future demands.

8.4 Ease of Use

Teachers and administrators are often initially reluctant to use technology, particularly if they have never used it before or seldom use it. Technology can be difficult to use and complex to operate. Good design can mitigate complexity, so careful attention to human factors can make systems easier to use.

Attention to ease of use can dramatically reduce training and support costs and improve productivity and acceptance.

8.5 Support for Existing Resources

School districts have already spent considerable sums of money over the last fifteen years to purchase technology. Recent surveys such as the CABE survey have determined that much of the equipment in the schools is already out of date. The existing equipment must be used in the best way possible during the upcoming years as these guidelines assist the development of new school facility infrastructures and replacement of the older technology components.

Whenever possible, the infrastructure should use existing resources to lower overall cost and speed implementation. Existing resources should be incorporated within the overall design or redeployed to functions that enable the older technology to be used to best advantage.

8.6 Reliability/Availability

Reliability and system availability are major issues. The computers and communications systems of today are very reliable and can be made more reliable through proper infrastructure management. Reliability is usually measured by how much time a system is available to perform its function. Support personnel are key to ensuring continued operation and expansion of the infrastructures as the amount of technology utilized by the schools increase.

8.7 Security

Security is necessary to ensure that confidential information is protected from unauthorized personnel. Two basic types of security are:

- physical security
- logical, or network, security

Physical security prevents physical access to system devices or prevents their removal by unauthorized personnel. Logical, or network, security prevents unauthorized access over a network to data, programs, or other information deemed important. Increasing the level and scope of security increases system costs.

Trade-offs exist between ease of use and security. Increasing security makes a system more difficult to use because it introduces a series of barriers that authorized users must navigate to reach the information they need.

8.8 Cost of Ownership

When comparing costs among different options, the overall life-cycle cost of ownership should be examined. This method takes into consideration all the aspects of the system, including original purchase, installation, operation, maintenance, support, and training. "System" is meant to include any hardware, software, and components necessary for the proper delivery of desired services. Useful life should be estimated using GAP guidelines, technological life, a combination of these, or some other defined criteria. The life-cycle cost of ownership accurately reflects true costs over the life of the system.

Cost of ownership includes the following components:

- *equipment (hardware)* -- the physical components of the system
- *software* -- the operating systems, layered products, tools, etc.
- *personnel* -- staff required to accomplish the tasks associated with the system from installation through ongoing operation at all involved sites
- *communications* -- costs for telephone circuits, dialup use, access, etc.
- *installation* -- the cost of installing all system components
- *hardware maintenance* -- the cost of post-warranty maintenance on all system components
- *software support and upgrades* -- including, but not limited to, the cost of upgrades, fixes, and support for all software operating on the system
- *training* -- the cost for initial and subsequent training on the system as needed
- *insurance* -- the cost to insure the system and its components against various perils

- *related expenses* -- costs related to acquiring, installing, and operating the system that are not the responsibility of the system vendor or vendors (An example of this type of expense is construction costs for building, remodeling, or retrofitting a facility to accommodate the system and/or its components. This could be anything from putting shelves in a closet to building a computer room complete with air conditioning and security systems.)
- *financing costs* -- the cost above the actual procurement cost for the system (depending upon the mechanism used to fund the system, this could include bond costs, lease charges, rental fees, interest charges, etc.).

A life-cycle cost, based on these factors, will accurately reflect the true cost of the system.

8.9 Professional Development and Training

Training will provide each school's staff the ability to maintain, reconfigure and sustain use and operation of the technology infrastructure. Two types of training are essential: maintenance/management training and operational training. Maintenance/management training deals with the overall maintenance and management of the infrastructure. Operational training deals with the day-to-day use of the infrastructure and the various systems it supports. A syllabus of the training to be provided should be reviewed and approved by the school prior to the commencement of each training session. Each attendee should receive copies of the training materials.

8.9.1 Management Training/Technical Support

The school should have one staff member responsible for the overall management and maintenance of the technology infrastructure. However, two or three other key personnel should be trained in this area to provide additional support in the event of maintenance backlogs and staff absences. Also, having more than one person trained will provide continuity within the school in the event personnel are reassigned.

Management training should include the following elements:

- overview of network architecture, including description of all components and their interconnection
- cable management including drawing, labels, patch panels, and location of outlets
- patching and reconfiguration concepts and techniques
- basic troubleshooting techniques for locating cable opens and shorts
- information on warrantee of components and suppliers of repair and replacement parts

8.9.2 User Training

Almost every administrator, student, teacher, and staff member will use one or more of the school's technology systems on a regular basis and will need training/professional development to acquire basic operational skills and competencies. Training should be given to all members of the school community who may use a particular system. For example, it may be that only the custodial staff will receive training for operating the energy management system while the entire administration, faculty, and student body would be given opportunities to learn to use the media retrieval and phone systems. Each building should have a resource person who has overall knowledge about the use of the school's technology systems and can answer basic questions at the point of need. Ongoing training/professional development must be provided in response to the increasing technology literacy of students and staff and as new technologies or applications are integrated into the system.

User training should include the following elements:

- overview of the technology system features, access procedures, applications, and limitations
- hands-on opportunities to learn and develop proficiency in using the system features
- printed materials delineating important information and troubleshooting procedures
- an overview of the ethics of responsible network use

8.10 Maintenance and Service

The technology infrastructure is only valuable to students and staff if it is fully operational. Maintenance and service of the technology infrastructure must be a high priority.

Initial maintenance and service of the technology infrastructure and its associated equipment, usually one year from the date of acceptance, should be included as a part of the original installation agreement. The maintenance and service should include maintenance and service for all components and include all parts and labor.

After the initial year of support from the installer expires, it is critical to have ongoing maintenance and service provided for the technology infrastructure. Usually, school districts use one or a combination of the following strategies to accomplish the service and maintenance:

- district technical support staff
- shared technical support staff with other districts, regional educational service center, or other agencies
- competitively bid maintenance and service agreements

9. LOCAL-AREA NETWORK OPTIONS

Most modern schools have some degree of voice and video technology, and many already have data networks. The issue is not so much whether schools should have these technologies but rather one of establishing or updating them to an appropriate level; a level that ensures an equitable, cost-effective distribution of the technology to meet the burgeoning management, teaching, and learning goals of the schools.

Computer technology is burgeoning into every teaching level and has advanced from an on-screen data display to include bidirectional voice, video, and data transmission. Because each media has its own electrical characteristics and must be served by an appropriate information transporting system, these advancements require a more comprehensive cabling system or physical plant.

Building networks generally start at the main distribution frame that forms the interface or termination between the building network and the outside voice, video, and data networks. The horizontal wiring subsystem radiates out from the distribution frame to the outlets in individual rooms. The work area wiring subsystem addresses the connection from the wall plate to the desktop computer or other technology device. Larger buildings will have a building backbone subsystem that connects multiple horizontal wiring subsystems. For facilities with multiple buildings, a campus backbone subsystem connects all the buildings into a single network. An administration subsystem includes the cross-connects and interconnections for the distribution subsystems.

Physical Connectivity

LANs provide three methods for **physical** connectivity (see Figure 3-1):

- *Bus* -- All devices share the same circuit.
- *Star* -- One device is chosen as the center and all others connect to it.
- *Ring* -- All devices share the same circuit, forming a ring.

Logical Connectivity

A network can form a **logical** bus, star, or ring. No direct relationship need exist between logical and physical network topologies. For example, Ethernet is *logically* a bus network; however it can be wired *physically* as either a bus or a star. Likewise, Token Ring is a *logical* ring, but its elements can be wired as a *physical* ring or, more commonly, as a *physical* star.

Physical stars form the most flexible data and voice distribution topology because they can accommodate *logical* bus, star, or ring networks. Coaxial cable is *logically* a bus, but often is implemented through a variation of the star topology called a tree, where the base of the tree is referred to as the head end. Any one or combination of these topologies can be used.

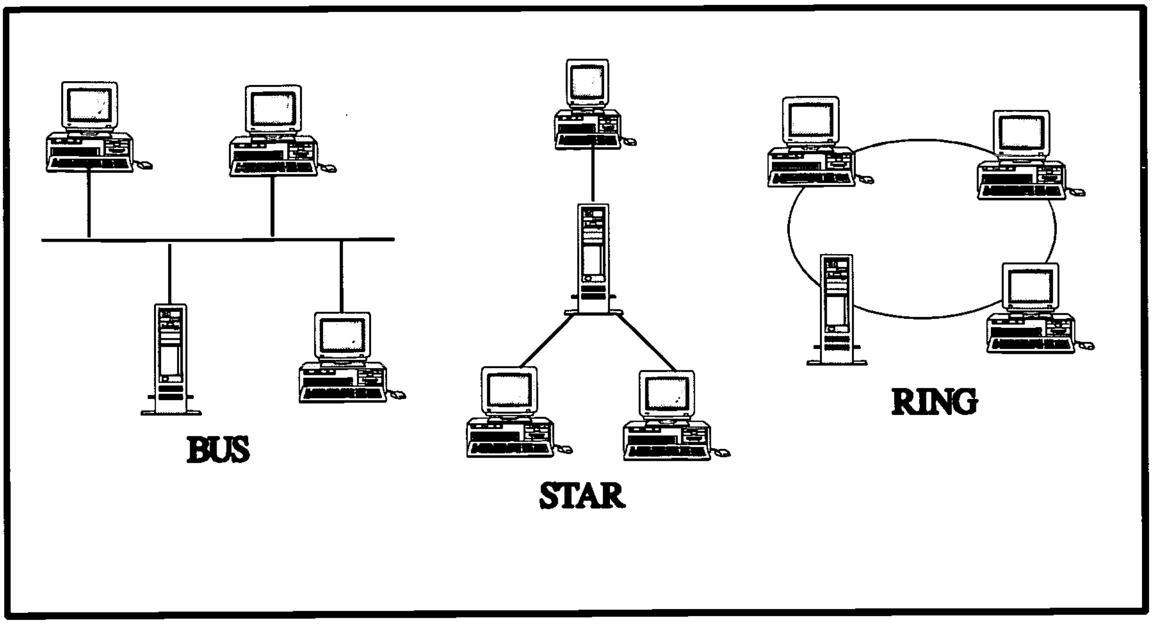

Figure 9-1: Network Topography

Devices

The information infrastructure of a comprehensive LAN must support a range of devices having different demands, for example:

- voice
  - analog telephone and telefax
  - integrated services digital network (ISDN) telephones
  - voice mail
  - other
- video
  - monitors
  - cameras
  - VCRs
  - videodiscs
  - video file servers
  - CODEC
  - other
- data
  - Macintosh computers
  - PC-compatible computers
  - printers
  - modems (translate analog to/from digital)
  - other

LANs create a physical infrastructure that can enable desktop computers and other technology devices to share the network services or resources, a much more economical arrangement than purchase of individual resources for each workstation or user. Examples of typical services that might be shared in a school include:

- voice services
  - key system, PBX, or Centrex
  - fax
  - voice-mail system
  - other
- video services
  - satellite dish
  - cable TV
  - ITFS
  - other
- data services
  - file servers/print servers
  - CD-ROM servers
  - communications servers
  - other

Various combinations of these voice, video, and data services can be employed, depending upon the individual school environment.

9.1 Distribution Frame Connectivity

Building cable infrastructures service the rooms from a distribution point or wiring closet that contains cable connection points called patch panels. This cable origination point of the voice, video, and data cabling plant is defined as the horizontal distribution frame (HDF), also known as the main distribution frame (MDF). This is where the building cables originate, traverse through the building hallways, and connect to the room outlets. This is also where external network connections attach to the building network wiring.

Cabling from a main distribution frame (MDF) to a room outlet, including extension to a utilization device, must be less than 90 meters (approximately 290 feet) in length. Where greater distance is involved, a main distribution frame and one or more secondary distribution frames may be required, as treated in section 3.2. Optional methods for connecting MDFs to room outlets follow.

9.1.1 Option A: Unshielded Twisted Pair (UTP)

Option Description	Unshielded twisted pair (UTP) Category 5 cable can be used to carry voice, video, or data from a MDF to a room outlet.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Most flexible.
Expandability/Breadth	Up to 90 meters.
Ease of Use	Must be professionally installed and tested.
Existing Resource Usage	UTP cable exists in many buildings, but generally was installed for other purposes.
Reliability/Availability	UTP is readily available, bu t it is susceptible to interference from motors and other sources of electromagnetic interference (EMI). Proper installation reduces this problem.
Security	Unauthorized access (tapping) or connection is relatively easy.
Cost	Least expensive of the options (for voice/data).

9.1.2 Option B: Shielded Twisted Pair (STP)

Option Description	Shielded twisted pair (STP) wire can transmit high-speed voice, video, and data similar to UTP. It is better suited than UTP for situations where high EMI might cause signal integrity problems. However, the cost and cable thickness are both greater than the more commonly used UTP.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Moderately flexible.
Expandability/Breadth	Can transmit data at high speed and greater distances than UTP.
Ease of Use	STP cable thickness (mentioned above) makes it more difficult to install or alter than UTP, which suggests careful consideration of future needs at time of network planning.
Existing Resource Usage	Very little STP wiring exists in schools due to the inherent higher cost.
Reliability	Much less susceptible to EMI than UTP.
Security	Unauthorized-authorized connection or tapping is somewhat more difficult to accomplish than with UTP.
Cost	Higher cost of cable and installation than UTP.

9.1.3 Option C: Fiber-Optic Cable

Option Description	Fiber-optic cable can carry conventional voice and video if digitized or changed to analog signal, and can transmit data at high speed. Active equipment is required at both ends to change electrical signals into light signals and the reverse.
Note	Asynchronous Transfer Mode (ATM) holds much promise toward merging voice, video, and data for transmittal over fiber-optic cable, and it may become cost-effective for schools in the future.
Decision Point	Prior to design-installation of new networks.
Evaluation of Option:	
Flexibility	Not compatible for existing telephones.
Expandability/Breadth	Great potential for high bandwidth.
Ease of Use	Most difficult to in stall and maintain.
Existing Resource Usage	Currently, little or no fiber optic cable in schools.
Reliability	Very reliable -- immune to EMI.
Security	Unauthorized connection is very difficult.
Cost	Higher cost than UTP and STP, and requires a more expensive workstation interface than cable.

9.1.4 Option D: Coaxial Cable

Option Description	Coaxial cable both RG-6 and RG-11 can easily transport broadband video between distribution frames. It can also carry voice and data if special devices are used to convert the signals to and from radio frequencies.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Does not support telephones.
Expandability/Breadth	Many channels can be added.
Ease of Use	Coaxial cable is difficult to install.
Existing Resource Usage	Existing coaxial cable must be tested for current applications.
Reliability/Availability	Reliable -- relatively immune from EMI. Components are readily available.
Security	Relatively secure from unauthorized-authorized tapping.
Cost	More expensive than UTP.

9.1.5 Option E: Wireless

Option Description	Wireless techniques are not (currently) suited for backbone network functions, such as distribution frame-to-room outlet messaging, and are cost-prohibitive for in-house multichannel two-way video broadcast.
Note 1	Wireless may become a viable option for mobile multiple data sourcing (within a room), as in a computer lab or media center, if and when its transmittal speed is significantly increased from the present 10 Mbps limitation.
Note 2	Nevertheless, when planning new LANs, consideration might be given to a wired location for an eventual room transceiver as this medium gains capability and reduces in cost.
Decision Point	Prior to design-installation of new networks.
Evaluation of Option:	
Flexibility	Greatest location flexibility. Except for power (unit-direct or battery recharge), transceivers can replace room outlet connectors, thus utilization equipment can be placed anywhere within a room or signal reception area.
Expandability/Breadth	Generally has lower bandwidth than hard-wired connections.
Ease of Use	Easy to install and use.
Existing Resource Usage	Makes little use of existing resources.
Reliability/Availability	Low present availability, less reliable than cable or fiber, and more susceptible to EMI.
Security	Dependent on broadcast technique --- spread spectrum is relatively secure, other techniques much less so.
Cost	Generally more costly for its delivered bandwidth.

9.1.6 Recommendations and Rationale

Recommendations for connecting main distribution frame to room outlets:
➤ Use UTP Level 5 cable for data and voice.
➤ Use RG-6 and/or RG-11 coaxial cable for broadband two-way video.

As of this writing, the most cost-effective LAN cabling solution would make use of unshielded twisted pair (UTP) cable for data and voice, and coaxial cable for broadband two-way video.

UTP cable offers good reliability and expandability. If necessary, its assignment can be interchanged between voice and data, and cable runs within wireways can be altered or added to much more readily than would be the case with the thicker, stiffer STP cable.

Coaxial cable provides greatest range and efficiency for video, which has become a vital tool in modern school teaching techniques.

If there is no current plan for wireless equipment, a wired but unpowered position might be included in a basic LAN design, in anticipation of the future availability of high speed-low expense broadcast equipment - room transceivers.

Although it is technically feasible to use only fiber-optic cable linkage between main and subordinate distribution frames, the active electronic (translating) equipment required is prohibitively expensive.

9.2 Connecting Distribution Frames and Buildings

When a school building is so large that it cannot be serviced from a single wiring closet without violating the 90-meter distance limitation from distribution frame to point of usage (workstation), multiple distribution frames are required.

One of these, at which all external network connections terminate, is designated the main (or horizontal) distribution frame (MDF). Each other subordinate unit is designated an intermediate distribution frame (IDF). If multiple buildings in a campus environment are involved in the computer technology, then each additional building must also have one or more IDFs.

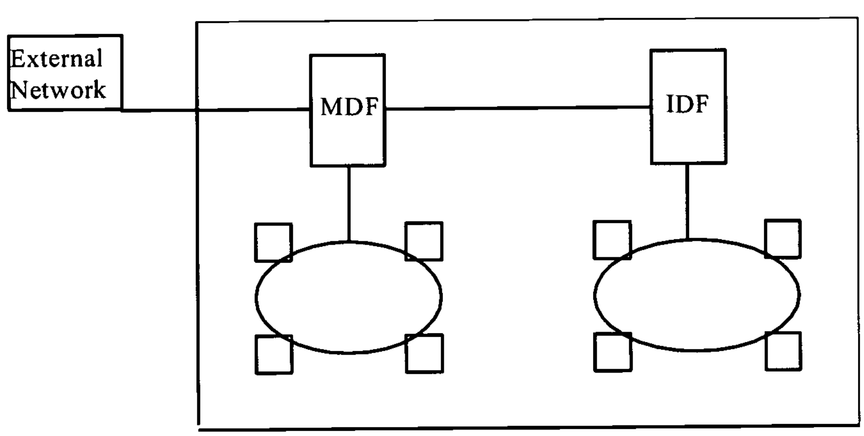

Figure 9-2: Distribution Frame Connections

All IDFs, wherever situated on the campus, must be connected to the MDF so that voice, video, and data can be distributed throughout the facility, and in reverse order through the MDF to external locations. IDFs are typically situated more than 90 meters away from the MDF, and there are several approaches for connecting them to the MDF, as discussed in following sections.

9.2.1 Option A: Unshielded Twisted Pair (UTP)

Option Description	UTP Category 5 wire, obtainable in 100 pair and up, can be used to carry voice from one distribution frame to another. However, due to distance limitations, high-speed data cannot go over this link.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Good -- supports both analog and digital (ISDN) voice.
Expandability/Breadth	Comes in many pair increments.
Ease of Use	Easy to install.
Existing Resource Usage	Existing distribution typically connected by UTP.
Reliability/Availability	Readily available but subject to EMI interference.
Security	Unauthorized access (tapping) is relatively easy.
Cost	Lowest cost alternative.

9.2.2 Option B: Shielded Twisted Pair (STP)

Option Description	STP wire can transmit high-speed video and data a further distance than UTP.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	STP does not come in 100 pair and up, as is normally used for connecting distribution frames.
Expandability/Breadth	Not as high capacity as fiber-optic cable.
Ease of Use	More difficult to install than UTP.
Existing Resource Usage	Not prevalent in many schools.
Reliability	Relatively immune t o EMI.
Security	Somewhat more secure than UTP.
Cost	More expensive than UTP.

9.2.3 Option C: Fiber-Optic Cable

Option Description	Fiber optic cable can carry high-speed voice, video, and data provided that video is digitized (expensive) or converted to an analog signal prior to transmission. Active equipment is required to change electrical signals to and from light signals.
Decision Point	Prior to design-installation of new networks.
Evaluation of Option:	
Flexibility	Fiber optic cable can handle longer distances than wire, and transmit at very high speeds.
Expandability/Breadth	Transmission speeds can reach gigabyte levels.
Ease of Use	More difficult to install than UTP or STP.
Existing Resource Usage	Very little fiber currently installed.
Reliability/Availability	Very reliable and immune from EMI. Fiber-optic cable is available - but expensive.
Security	Very secure and difficult to tap.
Cost	Relatively high, but the most economical on a cost to bandwidth basis.

NOTE: Although use of fiber optic cable for voice and video is cost-prohibitive at this time, sufficient fibers should be installed for future applications.

9.2.4 Option D: Coaxial Cable

Option Description	Coaxial cable easily transports broadband video between distribution frames. It can also carry voice and data if special devices are used to convert signals to and from radio frequencies.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Best for video.
Expandability/Breadth	Additional channels can be added to same cable.
Ease of Use	Somewhat difficult to install.
Existing Resources Usage	Significant amount of existing coaxial cable.
Reliability/Availability	Very reliable and relatively immune from EMI.
Security	Relatively secure from tapping.
Cost	Standardization by cable TV industry has reduced cost to a relatively low level.

9.2.5 Option E: Wireless

Option Description	In this section the term "wireless" means radio communication between two or more distribution frames. It is a very weak because: a) It is not suited for connecting distribution frames to one another within buildings. b) Even though voice and data can be broadcast between buildings, currently available (low-cost) technology limits transmittal speed to no more than 10 Mbps, with a distance limit of 1 kilometer. c) Multichannel two-way video can be broadcast between buildings, but suitable high power-high capacity equipment is expensive and (usually) subject to FCC licensing.
Decision Point	Consider at design stage of new networks.
Evaluation of Option:	
Viability	Wireless currently thought nonfeasible (cost and capability). Future developments bear watching.
Flexibility	Would eliminate interbuilding wire and cable.
Expandability/Breadth	Generally difficult to expand. Limited bandwidth.
Ease of Use	Relatively easy to use.
Existing Resource Usage	No known installations in Connecticut schools.
Reliability/Availability	Susceptible to EMI, but spread spectrum can mitigate interference.
Security	Spread spectrum is relatively secure, others le ss so.
Cost	Very expensive - considering the limited available bandwidth.

9.2.6 Recommendations and Rationale

Recommendations for backbones connecting multiple distribution frames:
➢ Use fiber optic cable for data. ➢ Use UTP Level 5 wire for voice. ➢ Use coaxial cable for broadband two-way video.

Currently, the most cost-effective solution for transfer of information between distribution frames is to use fiber-optic cable for data, UTP wire for voice, and coaxial cable for broadband two-way video. Supplemental wireless communication between buildings could be considered as an extreme remedy (i.e., where a lack of right-of-way prevents hard cable solutions).

9.3 Classroom Network Connections (Room Outlets)

Network cables should terminate at approved receptacles (room outlets), which provide flexible means for connecting user devices. Receptacles can be surface mounted on or flush mounted in walls, installed in wall mounted bezels, mounted on power poles (towers in central room areas), in or on cable conduit and wire molds, or on floor receptacle boxes. Receptacle location and user device connectors must meet applicable codes and safety standards. The following sections describe transmission capabilities for various receptacle/connectors.

9.3.1 Option A: RJ-45 Receptacles (Voice and Data)

Option Description	RJ-45 (8 pin) receptacles are well suited and have become a de facto standard for room outlet voice and data cable connection. A polarization key in this receptacle permits arrangement to accept either an RJ-11 (4 pin) male connector, or the (normal) RJ-45 (8 pin) male device.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Accepts both RJ-45 and RJ-11 male connectors.
Ease of Use	Easy to use.
Reliability/Availability	Reliable, readily available.
Cost	Comparatively low cost.

9.3.2 Option B: RJ-11 Receptacle (Voice only)

Option Description	The RJ-11 (4 pin) receptacle is currently used for voice transmittal only. There are a few older LANs that use RJ-11 connectivity for data, but with old style protocol and user devices that do not meet the newer data requirements.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Accepts only RJ-11 (4 pin) male connectors.
Ease of Use	Easy to use.
Existing Resource Usage	Most telephones now use RJ-11 connectors.
Reliability/Availability	Reliable, readily available.
Cost	Lowest cost.

9.3.3 Option C: ST Fiber-Optic Connector (Data)

Option Description	Previous sections recommend use of fiber optics as a **data** link between two or more distribution frames and not for direct connection to user devices. Where it is used an ST connector designed specifically for fiber-optic cable termination is the de facto standard.
Note:	Skilled technicians are needed to terminate fiber-optic cable and install ST connectors, which makes for elevated labor costs. And while the ST connectors are not expensive, translators used to convert light signals to and from electrical signals at each end of the fiber-optic cable does affect costs for use of this medium.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	ST connectors are non-flexible, in that they are required by and suitable only for connection of fiber-optic cable.
Ease of Use	Technically difficult to install.
Reliability/Availability	Most reliable connection.
Cost	Relatively low connector price, overall cost high.

9.3.4 Option D: SMA Fiber-Optic Connector (Voice)

Option Description	A sub-miniature assembly is a type of fiber-optic connector widely used in voice installations, before the introduction of the ST connector. Technical installation and translator cost factors are similar to those of the ST connector.
Note	Despite the SMA information in this section, it is UTP wire cable that is recommended for voice transmittal.
Decision Point	Prior to installation of new networks.
Evaluation of Option	
Flexibility	Usage diminishing (see Ease of Use below).
Ease of Use	More difficult to use than ST.
Reliability/Availability	Connections not as solid a s with ST type.
Cost	Connector price less than that of ST type.

9.3.5 Option E: F-type Receptacles (Video)

Option Description	So-called F-type receptacles are extensively used with coaxial cable to serve video equipment found in most homes - on the back of television sets and VCRs. F-type connectivity is positive, but it requires a male member having relatively weak pins, not well suited to frequent connect & disconnect (plug-in) activity.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Same connector as found on most video equipment.
Ease of Use	Easy to use.
Existing Resource Usage	Standard on most equipment, and pre-formed cable lengths are readily available.
Reliability	Fine for semi-permanent unit installations, otherwise somewhat less reliable than the BNC due to potential damage of the male connector.
Cost	F-type receptacles are low in cost.
Other Considerations	Coaxial and fiber-optic cables that are utilized to carry video information to user devices (room outlets) require extremely precise connection to the respective LAN receptacles.

9.3.6 Option F: BNC Receptacles (Video)

Option Description	As with F-type connectors, the BNC receptacle is also used for coaxial cable connectivity. It is a better choice for patch cables if devices will be subject to repeated connection and disconnection.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Not as flexible because most equipment is factory equipped with F-type connectors.
Ease of Use	Easiest to use.
Reliability	More reliable than F-type as a plug-in connector.
Cost	More expensive, often due to need for F-type to BNC adapter for each user device.

9.3.7 Recommendations and Rationale

Recommendations for room outlet connections:
➤ RJ-45 connectors are recommended for voice and data.
➤ F connectors are recommended for video in the classroom outlets.
➤ BNC connectors are recommended for patch panels.
➤ ST connectors are recommended for fiber optic cable.

9.4 Distribution Frame Layout

Each distribution frame represents the focal point of a LAN structure. It is the origination point for all wiring that emanates from it to the room outlets. The result is a large number of data and voice cables that require terminal connection to the distribution frame.

Distribution frames are equipped with patch panels to enable orderly connection between the building cables and system devices such as network hubs, PBXs, etc. Patch panels provide a simple means to perform additions, changes, and relocation of the connection point for voice and data network devices.

9.4.1 Option A: Building Cable Patch Panels, Voice/Data

Option Description

Modular patching provides simple wiring closet cross-connects that can be user-controlled with little experience or skill. Building cable patch panels provide an easy means for locating a specific room cable terminal end at its MDF or IDF distribution point. By relocating patch cords, cables can deliver selected services and any desk top device can be located at any network outlet.

9.4.2 Option B: Systems Connect Patch Panels, Voice/Data

Option Description

The Systems Patch Panels represent the connection points where network devices such as hubs, file servers, bridges, routers and other building resources interface with the previously described "Building Cable Patch Panels."

9.4.3 Option C: Direct Cable Connect Layout, Voice/Data

Option Description

An alternative to cable connection by means of patch panels and cross-connects would be direct connection to the established source devices. This hard-wired approach requires that all devices be firmly identified and their location planned as part of the installation design. Hard wiring does not support reconfiguration or device relocation.

9.4.4 Recommendation and Rationale

Recommendation for distribution frame layouts:
➢ Distribution frames should include building cable patch panels and systems connect patch panels.

Patch panels greatly facilitate management of the technology system, reconfiguration of network cabling, and relocation or update of user devices.

9.5 Video Distribution

A video system "head-end" need not be located in the same wiring closet as the voice and data systems. The video head-end should be in close proximity to the media center, where video programming is usually undertaken, and where other video resources are generally stored. A decision to locate the video head-end elsewhere than at the MDF should be based on the planned interaction of video control. If video programming is fixed and requires no interaction, head-end placement near the media center will provide no significant advantage.

Video can be either baseband or broadband, and it can be one-way as with typical home television or bidirectional as with many of the newest communication devices.

9.5.1 Option A: Broadband Distribution -- One-Way Video

Option Description	One-way broadband video cable enables simultaneous distribution of multiple source programs throughout the LAN, via radio frequency (RF) modulation to a standard VHF broadcast frequency.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Lacks flexibility of two-way video.
Expandability/Breadth	Standard broadband distribution is capable of simultaneously modulating 12 VHF channels. A greater number of channels can be modulated if the mid- and super-band frequencies are utilized (as with existing cable television systems).
Ease of Use	Relatively easy to use.
Existing Resource Usage	Any standard VHF television receiver can be used to view the desired program by selecting the appropriate VHF channel.
Reliability/Availability	One-way broadband cabling is reliable, and can be viewed on any common TV receiver.
Security	Somewhat difficult to tap.
Cost	This standard cable TV technology keeps costs down.

9.5.2 Option B: Broadband Distribution -- Bi-directional Video

Option Description	Bi-directional broadband video distribution is very much like the one-way system, except that the cable structure is transmission-signal-balanced to allow program generation from any of the room outlets back into and throughout the network.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Most flexible -- can support two-way video and, with added equipment, two-way data and voice.
Expandability/Breadth	The ability to generate (as well as receive) video programs provides the school with many added capabilities, such as teleconferencing, distance learning, and a potential for distribution of school-generated programs via local cable TV for townwide viewing.
Ease of Use	Relatively eas y to use.
Existing Resource Usage	Any standard receiver (e.g., television, VCR) can be used with this cabling system.
Reliability/Availability	Reliable, little susceptibility to EMI.
Security	Somewhat difficult to tap.
Cost	Bi-directional broadband cabling is standard cable TV technology — minimally higher in cost than a one-way broadband system.

9.5.3 Option C: Baseband Distribution Video

Option Description	With baseband distribution the cable handles only a single video signal, commonly by means of fiber-optic or coaxial cable.
Decision Point	Prior to installation of new networks.
Evaluation of Option:	
Flexibility	Non-flexible, only a single program can be transmitted at a given time, on a given cable. Bidirectional video is not possible with this system.
Expandability/Breadth	Video switches can be utilized to control the room outlets to which a given program is delivered.
Existing Resource Usage	If different rooms are to see different programs, then each room outlet cable must be home run to the MDF or head-end room.
Reliability/Availability	Reliable, with little susceptibility to EMI.
Security	Somewhat difficult to tap.
Cost	Cost depends on design. Single program viewing for all rooms can be lowest cost but with lowest flexibility. If each room is home run to the MDF, this system can be more costly than others.

9.5.4 Recommendation and Rationale

Recommendation for video distribution:
➢ Video distribution by bidirectional broadband cabling is recommended.

A bidirectional video distribution system offers maximum versatility and control at a very economical cost.

9.6 Room Network Jacks

This section covers the two options within the EIA/TIA 568 standard for terminating voice, video, and data cables. Polarization options should be considered as a basis for compliance to accepted standards, and from the aspect of functionality.

9.6.1 Option A: EIA/TIA 568-A, Voice/Data

Option Description

The Electronic Industries Association (EIA) 568-A termination sequence has become the widely specified sequence for new data installations. It is ISDN sequence compatible and a subset as detailed by IEEE 802.3 10BaseT Ethernet over twisted pair specification. This sequence is applicable to 8 wire polarization.

This termination sequence provides compatibility to the USOC specification that provides for both voice and data circuit compatibility with most installed wiring.

9.6.2 Option B: EIA/TIA 568-B (AT&T 258A), Voice/Data

Option Description

This specification is identical to the EIA 568-A specification except that pairs 2 and 3 are transposed. This provides backward compatibility to the USOC specification and the AT&T 258A specification which many existing infrastructures use.

9.6.3 Option C: Fiber Optic Cables

Option Description

The termination of fiber-optic cables is a specialized procedure that requires trained technicians. Polarization or termination sequencing is not applicable to fiber -optic cables. However, proper optical interfacing with the ST or SMA connector is critical to the functional performance of the cable to the connector interface. Improper alignment or contamination of the fiber to the connector interface will result in unwanted reflections that will attenuate the signal as it is transmitted.

9.6.4 Option D: Video Cables

Option Description

Like fiber -optic cables, there is no sequence-related specification for video coaxial cables. The coaxial center conductor must be attached properly to the F-type or BNC connectors center conductor, and the cable's outer shield must be connected to the connector's outer shield. Care must be maintained when making these connections so as not to disturb the spacing between the center conductor and the outer shield as this spacing is critical to the efficiency of the transmission path created by this type of cable.

9.6.5 Recommendation and Rationale

Recommendation for room network jacks:
➤ Use of the EIA/TIA standards is recommended for UTP and STP cables.

The use of the EIA-568A termination sequence for UTP cables is recommended because it provides the most adaptability to existing cable infrastructures. Also, the ability to allow either voice or data communications interchangeably adds to the versatility of the cable infrastructure.

9.7 Testing Infrastructure Wiring

The establishment of standards that can be measured for the various cable types employed in this system is needed to allow the installation of cable infrastructures independent of transmission protocol and usage.

9.7.1 Recommendation and Rationale

Recommendation for cable plant certification:
➤ Infrastructure should be certified and tested according to industry standards.

Appropriate industry standards are recommended for testing infrastructure wiring. This approach will provide the best functional verification of the installed system and provide corrective recourse if problems are encountered during the activation phase of the project.

9.8 Cable Management

One of the most important components of a structured cabling system is proper cable management. A poorly maintained termination point can quickly lead to chaos with the MDF or IDFs. These problems can be minimized by using the proper cable routing equipment and guides to prevent huge cabling snares and unmanageable tangles. Careful and logical cable numbering and tagging is also important to cable management. The following options should be considered.

9.8.1 Option A: Building-Specific Cable Management

Option Description	This approach requires that the cable number be defined by wiring closet location number, room termination number, and cable usage. This system employs an intelligent numbering scheme that allows the cable number to describe significant information regarding its start, stop, and network utilization.

9.8.2 Option B: Installer-Specific Cable Management

Option Description

The installer-specific cable numbering scheme is a simpler arrangement because the cables are numbered sequentially as they are installed. This approach is useful for identification of the cable at both ends of its run. It would require an as-built drawing to decipher the location of the start and stop points of the cable run.

9.8.3 Recommendation and Rationale

Recommendation for cable management:
➢ The building specific cable management scheme is recommended.

The building-specific cable management scheme is a more intelligent means to identify the cables as they run throughout the building. Also, use of the intelligent numbering scheme allows for identification of the cable start and stop locations without maps or cross-reference charts. Reference should be made to the EIA/TIA - 606 Cable Management standards.

9.9 Strategies for New and Existing Buildings

When considering the installation of a building-wide cable infrastructure, determination must be made as to whether the entire facility should be cabled exactly the same or whether allowances should be made for existing cable structures.

9.9.1 Option A: Utilize Same Standards for Both New and Existing Buildings

Option Description

Advantages exist in requiring that the cable plants for both new and existing buildings be created the same. The one set of design criteria would simplify the application of a common cable infrastructure. Additionally, all cables would be installed and tested under the same guidelines.

9.9.2 Option B: Utilize Existing Network Wiring Where Feasible

Option Description

An alternate approach to the building wiring layout would be to integrate existing network cabling infrastructures that meet a minimum level of performance. This might result in significant cost savings to the schools as previous building cabling could retain its utilization and be integrated to the new cable plant.

9.9.3 Recommendation and Rationale

Recommendation for network wiring:
➢ Use of existing network wiring must meet minimum performance standards and testing criteria.

The utilization of existing network wiring must be planned wherever the minimum operational level of performance can be established. This use of existing network cabling structures should provide a cost savings that could be applied in other technology areas.

10. OTHER CONSIDERATIONS

The increase of technology devices in the school building will result in locations throughout the building where power requirements will need to be supplied. As a result, the current capacity, condition, and placement of power wiring in schools and district offices must be examined and may need to be updated. The examination and recommendations for specific changes to a facility should be obtained from licensed professionals such as electrical engineers or engineering companies.

10.1 Electrical Power

The three principal attributes to consider for power are: quantity, quality, and reliability.

- *Quantity of electrical power* -- With increased technology, adequate power must be included in facility design. Considerations are for the number of outlets and circuits.
- *Clean power quality* -- The electrical power quality is important to most electronic devices today. The need for a power supply source that is free of harmful electrical spikes, noise, and power fluctuations becomes more important as the number of electronic devices become attached to the power circuits.
- *Power reliability* -- A constant of the technology era is the need for electrical power to fuel the technology devices that will allow us to navigate the technology highways. The sudden interruption of this power supply can cause software and/or hardware failure.

10.2 Furniture and Space

10.2.1 Furniture Requirements

Schools need to plan for the placement and location of technology devices. Some technology equipment will require special furniture. Also compliance to ADA specifications must be maintained.

Local school districts should review existing furniture and space for their ability to support new technology and their ability to accommodate ADA and state space requirements.

10.2.2 Space Requirements

Some schools already have space problems resulting in overcrowded classrooms and too few specialty areas. The addition of technology devices presents a location problem that must be addressed. Even in schools where space had not been a problem before, the addition of classroom technology devices such as computers and video monitors will require a re-evaluation of available space.

10.3 Heating, Ventilation, and Air Conditioning

The conditioning of the air within a school building encompasses the aspects of temperature control, air flow (supply of fresh air), and humidity control. Most school buildings in the state do not have true air handling systems. Many are arranged with heating plants only. In these buildings the dependence is on natural convection to provide air flow. There is little or no humidity control in the older buildings. Heat from technology equipment and from the users can be controlled through a well-designed heating, ventilation, and air conditioning system.

It should be noted that all facilities should have the HVAC capacity evaluated by professionals.

10.4 Other Environmental Issues

Other environmental concerns surround the increase of technology tools in the school building.

10.4.1 Background Noise

Technology devices generate noise. When they are installed in closed environments like classrooms, administrative offices, school library media centers, and the like, they can be a major contributor to unacceptable overall noise levels. Noise levels that are below but approach OSHA limitations can interfere with teacher-student communications or otherwise adversely affect the learning process, and thus require abatement.

A typical computer workstation with internal fans and hard disk drive produces a noticeable amount of noise. The user becomes accustomed to the level of the noise. In fact, when a student is deeply involved with the technology, sound generated at the individual workstation can smother the collective noise of the whole classroom, including generalized teaching instruction directed at the whole class.

To reduce background noise from technology, it is suggested that acoustical engineering services be included in facility planning. Flexible use of instructional space along with optimal placement of equipment also is recommended.

10.4.2 Room Lighting

The addition of technology devices in the classroom and other building areas can cause the lighting requirements to change. Considerations include screen glare, room darkening capability, placement of equipment, and large group projection capability.

GUIDELINES FOR TECHNOLOGY INFRASTRUCTURE IN CONNECTICUT SCHOOLS

APPENDICES

APPENDIX A

Glossary of Terms

Glossary of Terms

ADA

Americans with Disabilities Act

ANSI

American National Standards Institute. ANSI, a non-profit, non-governmental body supported by trade organizations, professional societies, and companies is the principle standard development body in the U.S. ANSI represents the U.S. to the ISO.

API

Application Programming Interface. Abbreviated API. A set of routines that an application program uses to request and carry out lower-level services performed by a computer's operation system. An application program carries out two types of tasks: those related to work being performed, such as accepting text or numbers input to a document or spreadsheet, and those related to maintenance chores, such as managing files and displaying information on the screen. These maintenance chores are performed by the computer's operating system, and an API provides the program with a means of communicating with the system, telling it which system-level task to perform and when. On computers running a graphical user interface such as that on the Apple Macintosh, an API also helps application programs manage windows, menus, icons, and so on. On local area networks, an API, such as IBM's NetBIOS, provides applications with a uniform means of requesting services from the lower levels of the network.

ASCII

American Standard Code for Information Interchange. A data transmission code of seven-bit characters with an eighth bit for error detection.

Assistive Technologies

The term assistive often applies to the kinds of technological tools available for students with special needs. Tools that enhance students' learning and communication are essential for children with special needs.

ATM

Asynchronous Transfer Mode. ATM switching protocol can handle all types of traffic; voice, video, data, and image.

AWG

American Wire Gauge. A standard specifying wire size; the larger the gauge, the smaller the wire.

Backbone

A high-speed connection within a network that connects shorter, usually slower circuits. NSFSNet is the principal backbone for the noncommercial portion of the Internet.

Backplane

A series of multiway sockets that are wired in parallel and are connected to the internal wiring of a computer or other electronic device. Peripherals may then be attached to the device (i.e. computer) simply by inserting compatible interface cards or modules into any one of the sockets.

Bandwidth

The amount of signal that can be processed by a given system (including the cable). Compare bandwidth to a highway; the bigger the highway, the greater the number of cars that travel on it at one time. The greater the bandwidth, the more information that can travel down the transmission channel at one time. Bandwidth for DATA is typically described as:

Kbs (kilobits per second)

Mbs (megabits per second)

Kbs (kilobytes per second)

Mbs (megabytes per second)

Baud

Symbols per second (data transfer rate).

Bi-directional Video

Video distribution in two directions which allows video material to be both received and originated from all locations.

Bit

A single piece of digital information. Represented by either zero or a one.

BNC Connector

A type of heavy duty video connector which is sturdier than the F-connectors typically used in home cable TV installations.

BOCA

Building Officials Code Administration.

BPS

Bits per second. A measurement of data speed. Can be preceded by K (kilo/thousands) or M (mega/million).

Bulletin Board System (BBS, bboard)

Named after a physical piece of board on which people can pin messages written for general consumption -- a "physical bboard." A computer and associated software that typically provides an electronic message database where people can login and leave messages. Messages are typically split into topic groups. A user may submit or read any message in these public areas. Apart from public message areas, a BBS may provide archives of files, personal electronic mail and any other services or activities of interest to the bulletin board system operator (the "sysop"). Thousands of local BBSs are in operation through out the world, typically run by amateurs for fun out of their homes on MS-DOS boxes with a single modem line each. Although BBSs have traditionally been the domain of hobbyists, an increasing number of BBSs are connected to the Internet, and many BBSs are currently operated by government, educational, and research institutions. Fans of Usenet and Internet or the big commercial time-sharing bboards such as CompuServe, CIX, and Genie tend to consider local BBSs the low-rent district of the hacker culture, but they serve a valuable function by knitting together lots of hackers and users in the personal-micro world who would otherwise be unable to exchange coding at all.

Use of this term for a Usenet newsgroup generally marks one either as a newbie, fresh in from the BBS world or as a real old-timer predating Usenet.

Byte

A device used to expand a LAN by selectively forwarding packets of data to another part of the LAN. It functions a smart repeater.

CAD

Computer Aided Design. Rhymes with "lad." Acronym for computer-aided design, a term applied to programs (and workstations) used in designing engineering, architectural, and scientific models ranging from simple tools to buildings, aircraft, integrated circuits, and molecules. Various CAD applications create objects in two or three dimensions, presenting the results as wire-frame "skeletons," as more substantial models with shaded surfaces, or as solid objects. Some programs can also rotate or resize models, show interior views, generate lists of material required for construction, and perform other allied functions. CAD programs rely on mathematics, often requiring the computing power of a high-performance workstation.

CAI

Computer Assisted Instruction. Direct instruction delivered by the computer.

CAM

Computer Aided Manufacturing.

CATV

Community Antenna Television. A television cable system which carries programs to home television sets. The cable is broadband in nature to carry numerous TV broadcasts simultaneously.

CC

Communications Closet - the CC acts as the distribution point for communications cable from the Communications Equipment Room to either the end user or to communications outlets in user areas. The CCs are centrally located near user areas and are connected to user areas via cable runs of no more than 290 feet.

CCTV

Closed Circuit Television.

CD-ROM

Compact Disc Read-Only Memory. A form of storage characterized by high capacity (approximately 600 megabytes) and the use of laser optics rather than magnetic means for reading data. Used frequently to provide access to encyclopedias, dictionaries, databases, and courseware. Information on disk is read-only and may not be changed or augmented.

CD-ROM Drives

The player for the CD-ROM disc.

Centrex

A type of telephone service offered by local telephone companies distinguished by the fact that the telephone equipment is located on the telephone company premise and thus requires no support operation by he user, and by the fact that there is no usage charge for monthly calls between numbers on the same CENTREX system. Telephone company monthly line charges are dependent on the distance of the end location from the telephone company central office.

Coaxial (Coaxial Cable)

A shielded cable used for video and low-level audio signals.

Transmission medium consisting of one wire conductor (two for twin axial cable) surrounded by a dielectric insulator and encased in either a wire mash or an extruded metal sheathing. Coaxial cable comes in many varieties, depending on the degree of EMI sheathing afforded and voltages and frequencies accommodated; also call "coax."

CODEC

Short for coder/decoder. A device which converts a analog signal into a digital data stream for transmission and converts incoming digital data into the corresponding analog form. The inverse of a modem.

Concentrator

A communications device which combines multiple input into a combined output, frequently referred to as a hub. Often used to connect multiple Ethernet devices to an Ethernet backbone.

Cross Connect Closet

A space containing equipment which connects separate cables from end locations to backbone cables which go to central audio, video, or computer equipment.

Cyberspace

Used by networkers to refer to the vast, worldwide reservoir of information being transmitted or stored by internet-worked computers. The term was coined by William Gibson in his fantasy novel, *Neuromancer* to describe the world of computers, and the society that gathers around them.

Dedicated Line

A communications link reserved for exclusive use by a group or individual for telecommunications. The user pays a set fee rather than per-call or per-minute charges for leased time.

Dialup Access

A temporary, as opposed to dedicated, connection between machines established over a telephone line using modems.

Distance Learning

A form of instruction whereby one instructor reaches many sites by telecommunications, satellite or video media.

DOS

Disk Operating System. A generic term describing any operating system that is loaded from disk devices when the system is started or rebooted. The term originally differentiated between disk-based systems and primitive microcomputer operating systems that were memory-based or that supported only magnetic or paper tape.

EIA/TIA

Electronic Industries Association. Develops and promulgates standards specifications and procedures for electronic equipment. TIA stands for Telecommunications Industries Association.

Electronic Mail

The transmission of correspondence by computer to all or selected terminals on a system.

EMI

Electromagnetic Interference - A device's radiation leakage that couples into a transmission medium resulting resulting from the use of high-frequency wave energy signal modulation. EMI is reduced by shielding. Minimum acceptable levels are detailed by the FCC and/or manufacturer specification.

Equipment Rack

A metal rack, usually in a standard 19" wide format defined by NEMA standards, used to hold various types of computer and communications equipment.

Ergonomics

The study of people in relation to their working environment. The goal of ergonomics is to incorporate comfort, efficiency, and safety into home and workplace environments.

F Connector

The type of video connector commonly used on home cable TV installations. It uses the soft copper center conductor of the coaxial cable as the center pin for the connector. The result is fragile and unreliable in constant duty use.

FCC

Federal Communications Commission - An independent government agency established by the Communications Act of 1934 to regulate the broadcasting industry. The Commission later assumed authority over cable. The FCC is administered by seven commissioners and reports to Congress. The FCC assigns broadcasting frequencies, licenses stations, and overseas interstate communications.

FDDI

Fiber-Distributed Data Interface. A network standard based on the use of optical-fiber cable to transmit data at 100 Mbps.

Fiber Optics

A general term describing the transmission of data by the use of modulated lightware signal, transmitted over glass or plastic medium, and received by light-sensitive receiver.

File Server

A file-storage device on a local-area network that is accessible to all users on the network. A file server is a sophisticated device that not only stores files but manages them and maintains order as network users request files and make changes to them. On local-area networks, a file server is often a computer with a large hard disk that is dedicated only to the task of managing shared files.

Gateway

A special-purpose dedicated computer that is node in two (or more) networks and routes packets from one network to the other. the two networks may use the same protocol of different protocols. The gateway has the name/address in EACH network and has to be running an implementation of each protocol. An Internet gateway (both nets are using the TCP/IP protocol) routes IP datagrams between the networks it connects. Gateways route packets to other gateways until they can be delivered to the final destination directly across one physical network.

Graphical-User Interface

Abbreviated GUI. A type of display format that enables the user to choose commands, start programs, and see lists of files and other options by pointing to pictorial representations (icons) and lists of menu items on the screen. Choices can generally be activated with the keyboard or with a mouse. Graphical user interfaces are used on the Apple Macintosh and by such programs as Microsoft Windows and the OOS/2 Presentation Manager.

Gopher

Software which permits searching files on remote hosts using layered menus. Text from these files can be read online or the files can be transferred to your computer.

HDTV

Abbreviation for High Definition Television. A new "proposed" standard for the broadcasting and display of television signals with twice the resolution of current broadcasting and display systems, 1100 lines of resolution in broadcast mode. HDTV is equal to current S-VGA for computers.

Head End

The location in a video distribution system that connects the equipment which originates all outbound signals and redirects all inbound signals to their proper outbound channel..

Home Run

A type of wiring system design in which the cable from each outlet is individually routed to a central location.

Hub

See Concentrator

HVAC

Acronym for Heating, Ventilation, Air Conditioning, and a term used by the building trades.

IDF (Intermediate Distribution Frame)

The room where a concentrator is located which connects data signals from local network outlets to a data backbone for transmission to the Main Distribution Frame (MDF).

IEC

International Electotechnical Commission.

IEEE

Institute of Electrical and Electronic Engineers. An international professional society that issues its own standards and is a member of ANSI and ISO.

Infrastructure

The basic facilities, equipment, and installations needed for the functioning of a system or organization.

ILS (Integrated Learning System)

A type of curriculum software characterized by the availability of comprehensive presentation of a complete curriculum, under the control of a management application which administers and tracks individual lessons.

Internet

The Internet is the largest network of computers in the world. It is a three level hierarchy composed of backbone networks (e.g., ARPAnet, NSFNet, MILNET), mid-level networks, and stub networks. These include commercial (.com or .co), university (.ac or .edu) and other research networks (.org, .net) and military (.mil) networks and span many different physical networks around the world with various protocols including the Internet Protocol.

Interoperability

The capacity of miltivendor computers to work together using a common set of protocols. When Interoperable , PCs, Macs, Suns, DecVAXen, CDCCybers, etc., all work together allowing one host computer to communicate with and take advantage of the resources of another. The TCP/IP and protocols are a major implementor of interoperability.

ISDN

Integrated Services Digital Network. A network able to receive inputs from a variety of sources (voice, data, text, facsimile, video, etc.) that are digitally encoded and transmitted over a common network and delivered in its original form at the destination. The basic rate interface supports two B channels (each 64 Kbps) and a D channel (16 Kbps) for signaling.

ISO

International Standards Organization

ITFS (Instructional Television Fixed Service)

A class of television service which uses microwave towers that must be within line of sight of each other. This class of service has been set aside for use by educational institutions.

LCD

Liquid Crystal Display. A visual display that uses an electric current to charge a thin layer of fluid that is trapped between two glass plates.

LED

Light Emitting Diode. A type of light, typically red in color, often used in combinations to indicate numbers or letters.

Local-Area Network (LAN)

A data communications network that is geographically limited (typically to a 1 km radius) allowing easy interconnection of terminals, microprocessors, and computers within adjacent buildings. Ethernet and FDDI are examples of standard LANs.

Logical Connectivity

The effective connection between network elements as seen by the user. The logical connectivity may be routed through switched or permanent physical connections which are different or varying.

MAN

Metropolitan-Area Network. A "stretched" LAN providing data communications over a distance of about 50 km, generally associated with the IEEE 802.6 MAN standard.

MARC Record

Machine-Readable Cataloging record. Machine-Readable means that one particular type of machine, a computer, can read and interpret the data in the cataloging record. A cataloging record is a bibliographic record, or the information shown on a catalog card.

Mbps

Megabits per second.

MDF

Main Distribution Frame. The central location where backbone connections to Intermediate Distribution Frames and local network outlets are terminated.

Modem

Acronym for MOdulator-DEModulator. A device to convert digital data signals to analog signals for transmission over an analog circuit and then turn the analog signals back into digital signals at the receiving end.

Monitor

A television that receives and displays baseband information only. i.e. direct feed from a VCR or laser disc.

Multimedia

Human-computer interaction combining two or more media (e.g. text, graphics, voice, and video). Often also includes concepts from hypertext. This term has come to be almost synonymous with CD-ROM in the personal computer world because the large amounts of data involved are currently best supplied on CD-ROM.

NEC

National Electrical Code.

Network

A group of computers and associated devices that are connected by communications facilities. A network can involve permanent connections, such as cables, or temporary connections made through telephone or other communication links. Networks are often classified according to their geographical extent: local-area network (LAN), metropolitan-area network (MAN), wide-area network (WAN), and also according to the protocols used.

OPAC (Online Public Access Catalog)

The contemporary electronic version of the library card catalog. Hundreds are currently connected to the Internet, including the Library of Congress OPAC, permitting extensive bibliographical research from any Internet connected computer.

Open Systems Standard

A set of standards for hardware and software which is based on industry standards and allow for the interconnection of equipment from various manufacturers.

OS

Operating System. Sometimes called the executive. The software responsible for controlling the allocation and usage of hardware resources such as memory, central processing unit (CPU) time, disk space, and peripheral devices. The operating system is the foundation on which applications, such as word-processing and spreadsheet programs, are built. Popular operating systems include MS-DOS, the Macintosh OS, OS/2, Windows, Windows NT, and UNIX.

Packet

The unit of data sent across a packet-switching network. The term is used loosely. While some Internet literature uses it to refer specifically to data sent across a physical network, other literature views the Internet as a packet switching network and describes IP datagrams as packets.

Patch Panel

A matrix of sockets that can be interconnected manually by means of patchcords, i.e. short cables with plugs on both ends.

PBX (Private Branch Exchange)

A piece of equipment which is controlled via software which connects phones together and controls how they operate. The term Private Branch Exchange describes an exchange which the local user controls.

POTS (Plain Old Telephone Service)

The traditional switched analog telephone service common in most homes.

Protocols

Conventions governing the transmission of data. (Communications Protocol) A set of rules or standards designed to enable computers to connect with one another and to exchange information with as little error as possible. The protocol generally accepted for standardizing overall computer communications is a seven-layer set of hardware and software guidelines known as the OSI (Open Systems Interconnection) model. A somewhat different standard, widely used before the OSI model was developed, is IBM's SNA (Systems Network Architecture). However, protocols exist with in protocols, all affecting different aspects of communication. Thus, the word protocol is used, sometimes confusingly, in reference to a multitude of standards affecting different aspects of communication. Some, such as the RS-232-C standard, affect hardware connections. Other standards govern data transmission; among these are the parameters and handshaking signals (such as XON/XOFF) used in asynchronous (typically, modem) communications, as well as such data-coding methods as bit-oriented and byte-oriented protocols. Still other protocols, such as the widely used XMODEM, govern file transfer, and others yet, such as CSMA/CD, define the methods by which messages are passed around the stations on a local area network. Taken as a whole, these various and sometimes conflicting protocols represent attempts to ease the complex process of enabling computers of different makes and models to communicate.

Punch Down Block

A matrix of connectors that is used to connect cables from terminal equipment to cables connecting to central equipment. Connections are made manually by pushing sort lengths of wire into metal slips on the punch down block with a tool. Less expensive and less easily changed than a patch panel.

PVC

Polyvinyl Chloride. The material most commonly used for the insulation and jacketing of cable.

RAM

Random Access Memory. Semiconductor-based memory that can be read and written by the microprocessor or other hardware devices. The storage locations can be accessed in any order. Note that the various types of ROM memory are capable of random access. The term RAM, however, is generally understood to refer to volatile memory, which can be written as well as read. Compare core, EPROM, flash memory, PROM, and ROM.

RG

Coaxial cable used for bidirectional video. RG-6 is usually used for individual drops to rooms and RG-11 is used for longer cable runs.

Ring Topology

A network topology in which each node is connected to two adjacent nodes. Example: Token Ring.

RISC

Reduced Instruction Set Computer. A type of microprocessor design that focuses on rapid and efficient processing of a relatively small set of instructions. RISC design is based on the premise that most of the instructions a computer decodes and executes are simple. As a result, RISC architecture limits the number of instructions that are built into the microprocessor but optimizes each so it can be carried out very rapidly usually within a single clock cycle. RISC chips thus execute simple instructions faster than microprocessors designed to handle a much wider array of instructions. They are, however, slower than general-purpose CISC (complex instruction set computing) chips when executing complex instructions, which must be broken down into many machine instructions before they can be carried out by RISC microprocessors. Families of RISC chips include Sun Microsystems' SPARC, Motorola's 88000, and Intel's I860.

RJ

Registered Jack. The most common jacks used for telephone and data are the RJ-11 (for three-pair connections) and RJ-45 (for four-pair connections).

Router

A device (sometimes a dedicated computer) within a network that forwards packets of data of a specific protocol type (such as IP) from one network to another. It processes the data to determine how to forward packets toward their destination.

Server

A computer which offers services to another computer; also the software which enables it to do so. The computer served is a client which runs client software to obtain the services. The workload involved in providing the services is thus divided between the server and the client. Telenet, ftp, and gopher are client programs which request services from remote servers.

Star Topology

A network topology consisting of one central node or hub with point-to-point links to several other nodes. Control of the network is usually located in the central node or switch, with all routing of network message traffic performed by the central node.

STP

Shielded Twisted Pair. Twisted-pair cable with either individual or overall shielding.

Switched Network

Any type of communication technique that allows signal on a single cable to connect to multiple destinations, either sequentially, as in a dial telephone system, or simultaneously, as in the Internet.

T

Digital transmission format prefix followed by code indicating bit rate.

T1

A communication line that carries data at 1.544 Mbps.

T3

A communication line that carries data at 44.736 Mbps (commonly called 45 Mbps).

TAP

A device used to assure proper signal levels when connecting individual video outlets to a backbone cable. The value of the tap must be calculated based on the length of the backbone cable and outlet cable to assure proper signal levels.

TCP/IP

Transmission Control Protocol/Internet Protocol. An internetworking standard originated by the U.S. Department of Defense and now controlled by the Internet Advisory Board.

Telecommunications

Long-distance communications using electromagnetic systems (including wire, e.g. telephone or telegraph) and broadcast transmission (e.g. radio, television, or satellite).

Token Ring

A type of local area network based upon the IEEE 802.5 standard, where a token must be received by the attached terminal or workstation before that terminal or workstation can start transmitting.

Topology

The physical and logical relationship of nodes in a network typically having a star, ring or bus configuration. Network topology can be centralized as in a star with a concentration point for all nodes or distributed as in a ring with point-to-point connections.

Twisted Pair

This type of wire consists of two insulated copper conductors that are wound around each other to reduce the effects of electrical noise. The two available types are Unshielded Twisted Pair, used by 10Base T, and Shielded Twisted Pair, used by Token Ring's type 1 cable and which contains wrap-around conductor or a foil used for noise reduction.

UHF (Ultra High Frequency)

A block of television channel frequencies 300 to 3,000 MHz.

UPS

Uninterruptable Power Supply. A device, connected between a computer (or other electronic equipment) and a power source (usually an outlet receptacle), that ensures that electrical flow to the computer is not interrupted because of a black out and, in most cases, protects the computer against potentially damaging events such as power surges and brownouts. Different models offer different levels of protection. All UPS units are equipped with a battery and a loss-of-power, it immediately switches over to the battery so that the user has time to save his or her work and shut off the computer. The amount of time the battery can sustain power varies with the model of the UPS; generally, higher-end models offer longer battery time. In addition, higher-end models have features such as power filtering, sophisticated surges protection, and a serial port so that operating systems capable of communicating with a UPS (such as Windows NT) can work with the UPS to facilitate automatic system shutdown.

UTP

Unshielded Twisted Pair. Twisted-pair cable without either individual or overall shielding.

Voice Mail

An ancillary system to a phone system which provides voice messaging capabilities to a voice system. Systems vary in number of uses and storage time.

Wide-Area Network (WAN)

A network, usually constructed with serial lines, extending over distances greater than one kilometer. Compare with local-area network.

Wiring Closet

A building location used to house across connect and distribution frame equipment.

100 BaseT

A high performance implementation of Ethernet which transmits data at 100 million bits per second, an alternative to 10 BaseT, which is only 10 million bits per second.

APPENDIX B

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APPENDIX C

Sample Facility Layouts

Sample Facility Layouts

APPENDIX D

Overview of EIA/TIA Standards

Overview of EIA/TIA Standards

While other sections of the EIA/TIA standards may prove useful, the following sections are the standards most commonly associated with telecommunications applications in public schools.

EIA/TIA 568: Commercial Building Telecommunications Wiring Standard

- Horizontal Wiring: Topology, Distances, Recognized Cables, Choosing Media
- Backbone Wiring: Topology, Distances, Recognized Cables, Choosing Media
- Work Area
- Telecommunications Closet Design
- Equipment Room Design
- Cable Specifications: Unshielded Twisted Pair, Shielded Twisted Pair, Coaxial Cable, Optical Fiber
- Telecommunications Outlets
- Connecting Points and Hardware

EIA/TIA 569: Commercial Building Standard for Telecommunications Pathways and Spaces

- Horizontal Pathways: Underfloor, Access Floor, Conduit, Cable Trays and Wireways, Ceiling Pathways, Perimeter Pathways
- Backbone Pathways: Intrabuilding Pathways, Interbuilding Pathways
- Work Station Pathways
- Telecommunications Closets and Equipment Rooms
- Entrance Facilities
- Firestopping
- Space Separation from Electromagnetic Energy Sources

EIA/TIA 570: Residential and Light Commercial Telecommunications Wiring Standard

- Limitations of EIA/TIA 570 and Guidelines for Applicability

EIA/TIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

- The Importance of Maintaining Cabling System Documentation
- Pathway Administration
- Cabling Administration

EIA/TIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications

- Components of the Telecommunications Grounding and Bonding System
- Entrance Facility
- Closets and Equipment Rooms

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