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SYSTIMAX® Building Automation Systems

Cost Reducing Construction Techniques for New and Renovated Buildings/Cost Models

White Paper
Issue 2
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SYSTIMAX® Structured Connectivity Solutions

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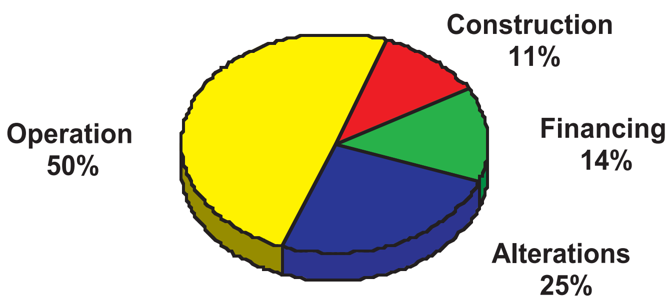
Contents

1. Introduction

There are many interpretations and definitions of an intelligent building. An intelligent building can be defined by the information and control services that meet the needs of the occupants, the software that controls telecommunications and building automation functions, or by the actual electronic hardware and devices implemented within the structure. It is necessary to have all of these components to create such a facility, but a Structured Connectivity Solution (SCS) is the common ingredient required to integrate the telecommunications (e.g., voice, data, video, etc.) and Building Automation Systems (BAS). Other than the SCS, these low voltage or power-limited services have nothing in common except similar transmission characteristics (i.e., analog or digital data signals), and the pathways (e.g., conduit, cable tray, raceway, and so on) that support and protect the cabling investment.

Providing an internationally standardized SCS and consolidating the horizontal pathways for all the systems can reduce the initial construction costs by 10-15%, and up to 30%, for the cabling infrastructure of a modern intelligent building. The actual level of savings achieved is dependent upon the configuration and the geographical pricing for material and labor. An integrated systems approach also enables management to quickly and cost effectively respond to the changing needs of the tenants, which impacts the cost to occupy the space. In some cases, additional construction expenditures for the SCS or BAS, such as devices to optimize the use of power consumption, may be necessary to reduce the operational expenses. However, the costs for cabling-related changes can typically be reduced by 25-40% for a new or renovated facility when using a total systems integration approach.

As can be seen from the graph below, typical costs for building operation and alterations over a 40-year life cycle far exceed the initial construction costs. Proper systems integration planning to optimize the construction process can reduce these on-going life cycle costs.



2. The Foundation for Systems Integration

For many years voice and data systems were cabled separately. Now it is standard practice to use a common SCS for both of these systems. Like the voice and data systems of the past, the traditional construction process separately installs each of the BAS disciplines under various divisions of a specification.
The BAS typically consists of:

- Fire, Life and Safety (FLS) or Fire Alarm (FA)
- Security and Access Control (SAC)
- Energy Management Systems (EMS), which includes Lighting Control
- Heating, Ventilation and Air Conditioning (HVAC)

Each of these BAS categories is typically cabled separately. The voice and data cabling is rarely addressed during construction and is usually not part of the construction budget. Planning and installation is normally accomplished when the floor space is being prepared for occupancy. This means multiple cabling systems and pathways are installed during various stages of the construction, which establishes one of the primary reasons for systems integration (i.e., integrated cabling and pathways instead of individual systems). Other reasons for integrating the BAS with the telecommunications include:

- BAS use data networking and LAN architectures (i.e., intelligent controllers and addressable devices). Ethernet-IP based controllers are readily available from multiple BAS vendors.

- BAS are increasingly being integrated into the primary data backbone, which allows controlled access through any PC on the data network.

With proper planning the only limiting factor for complete systems integration of the telecommunications and BAS may be the fire alarm system. In the United States, Article 760-54 (b) of the 1999 National Electrical Code (NEC) allows conductors of power-limited fire alarm systems and signaling/communications circuits (Article 725/800) to share the same cable, enclosure, or raceway. In addition, Article 760-61 (d) of the NEC allows the use of the same type of cable for a fire alarm that is typically used for the communications circuits. Some local codes however, especially codes in other countries, may invoke limitations or require special approvals for integrating the fire alarm system. Yet, even if the fire alarm cabling is installed separately, there are still substantial cost reductions and benefits that can be derived from integrating the remaining BAS (i.e., HVAC, EMS, SAC).

In addition to the code and standards requirements, there is also a need to evaluate the electrical characteristics of the systems. The voice and data systems primarily consist of analog and digital signals, and have established guidelines for signal strength over distance. The BAS devices operate on current draw, circuit resistance (contact closure), or consist of analog or digital signals (e.g., communications bus). Basically, each BAS terminal or device will operate over a particular cable type as long as it is located within a specified range from the equipment.

BAS devices are utilized to monitor or control a specific function. We can equate this to an output from the equipment or an input from a device. As an example, there may be a temperature sensor that gathers information and sends a signal to the equipment panel (input) and, as a consequence, the equipment sends a signal to a device that closes a damper or vent (output). Devices are primarily power-limited or communicate using low-speed protocols. The signal distance supported by the devices is usually limited by the current draw and line voltage delivered by the power supply. Typically, 24-AWG unshielded twisted-pair (UTP) cable has the capacity to handle 1 Ampere (Amp) of current draw per conductor, with a maximum of 3.3 Amps per four-pair cable.

What does this mean? The current or signal from the equipment leaves at a specified voltage level. The device requires a certain voltage level to operate. As the signal travels through the cable the voltage drops due to resistance. Cable pair resistance is measured by shorting one end of the cable and taking a resistance reading between the conductors at the other end. A typical 24-AWG UTP cable pair has 187.6 Ohms per kilometer or 0.1876 Ohms per meter (57.2 Ohms of resistance per one-thousand feet or .0572 Ohms per foot).
Circuit resistance can be measured by dividing the voltage drop by the current draw.

If a 24 Volt (V) device requires 50 Milliamps (.05 Amps) of current to operate and the allowable voltage drop is +/-10% or 2.4V, the maximum circuit distance using 24-AWG UTP cable is 256 meters (839 feet). This can be easily calculated for any cable and circuit using the following two step formula:

- Voltage Drop (2.4 V) / Current Draw (.05 Amps) = Circuit Resistance (48 Ohms)
- Circuit Resistance (48 Ohms) / 1 Meter Cable Resistance (.1876 Ohms) = Maximum Distance (256 Meters 839 Feet)

The BAS has evolved from individual systems using many different technologies to LANs and networks using intelligent controllers, just like today's data systems. The cabling choice for today's data systems is a structured UTP copper and fiber connectivity solution. This makes it a natural fit for the BAS and can substantially reduce construction and operational costs by planning and integrating all systems on a single cabling infrastructure.

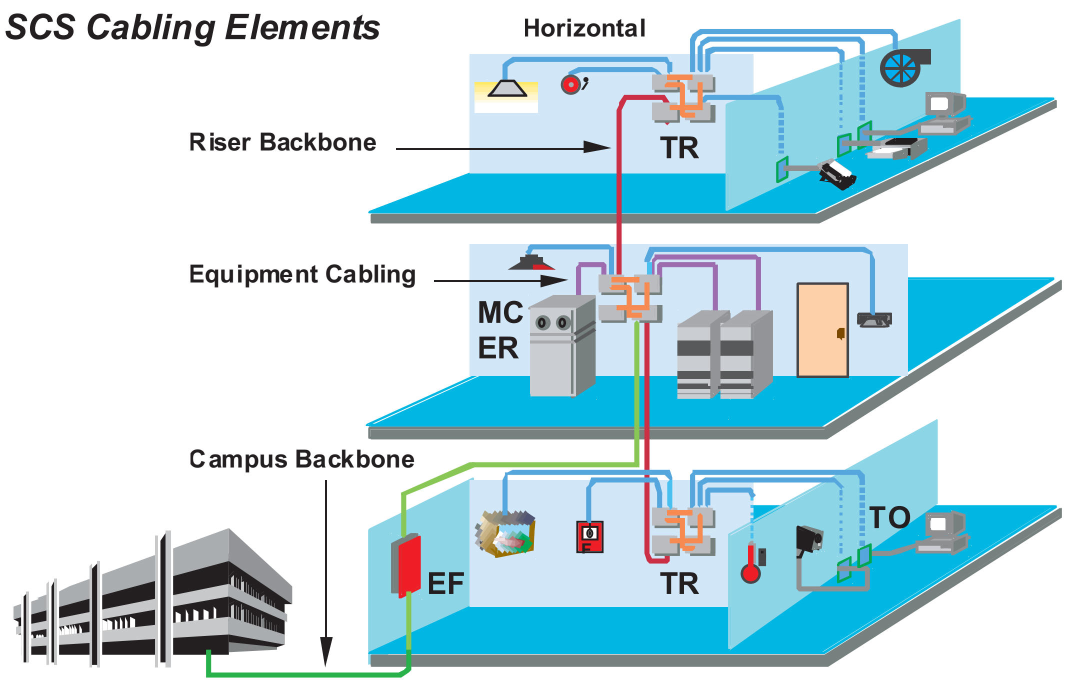
3. Planning

The previous statements have established that it is possible to use the same type of 0.51 mm (24-AWG) UTP cable and share a common cable pathway for all power-limited services. The next step is to determine the best way to perform systems integration. The process starts with early planning and a decision by the building owner or management to select the cabling as the first system. Once the decision is made to use a common cabling infrastructure, it is very easy to select voice, data, video, and BAS equipment that is compatible with the cabling. In fact, the sooner the consolidation of cabling systems and pathways is considered, the greater the potential savings and flexibility.

The Telecommunications Industry Association/Electronic Industries Association (TIA/EIA) and International Standards Organization/International Electrotechnical Commission (ISO/IEC) have created industry standards for cabling telecommunications systems. These standards address the cabling and pathways (i.e., pathways and spaces), and are based on a subsystem architecture or structured cabling elements, which is shown on the following page. Prior to the standards, the subsystem concept was first used for voice systems. During the 1980s it was also adopted for data systems. Like the BAS equipment of today, there were many different types of cables and wiring methods for data systems before the standards were established. Data networks were typically unmanageable, with little or no flexibility, and new cabling was often necessary when systems were changed or upgraded.

With some slight modifications (e.g., use of a coverage area versus a work area), the TIA/EIA and ISO/IEC documents can also be used to provide the same standardized cabling architecture for the BAS devices, systems, and applications. This has led to the development and recent publication of the ANSI/TIA/EIA-862 Building Automation Cabling Standard. This standard specifies a generic cabling system for BAS used in commercial buildings that will support a multi-vendor environment. The purpose of this standard is to enable the planning and installation of a structured cabling system for BAS applications used in new or renovated commercial premises. It establishes performance, topology and technical criteria for various cabling system configurations for connecting BAS equipment and devices. It also provides information that may be used for the design of commercial BAS products.

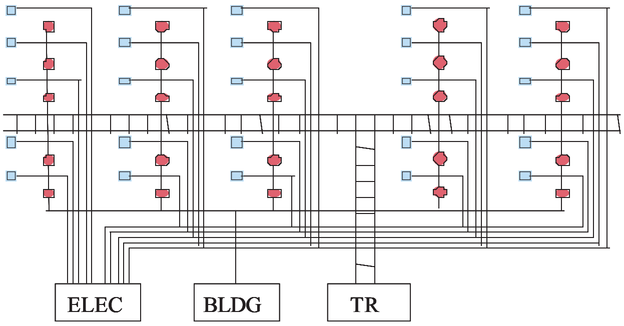
The horizontal cabling and pathways can be designed for all the services with the Telecommunications Room (TR) as the terminating point. This is the key to the integration of cabling and pathways. The wallfields/distribution frames at the TR location can be combined for maximum flexibility, or individual termination fields can be established within the same TR. Therefore, a secure area for all cabling is created, thus reducing the multiple spaces required for traditional separate installations. Maintenance is also simplified since all systems are located in a common area.



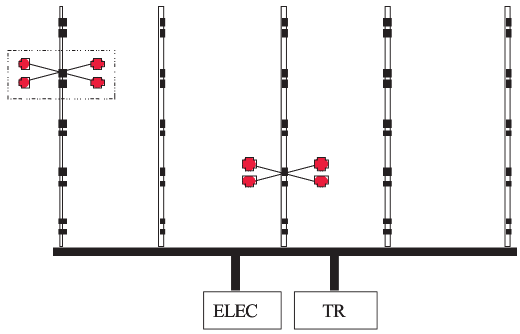
This also allows a single pathway to be designed for supporting the various horizontal cables in the workspace. It can even be taken a step further by incorporating the power for lighting and receptacles from the electrical panel into a modular partitioned raceway. This could be used instead of a traditional hardwired installation consisting of several conduit and cable tray systems for the voice, data, video, BAS, and electrical services.

Case studies show that an integrated approach can provide up to 30% construction savings for cabling and pathways when a single high/low voltage cabling infrastructure is implemented. The savings will vary according to geographical costs for material and labor. Material costs will typically be higher than a traditional separate systems installation, but labor hours can typically be reduced by as much as 50%. This could not only mean substantial construction savings, but also allows the building to be occupied sooner, resulting in additional rental or lease revenue.

Even if an integrated high/low voltage raceway system is not utilized, the pathways may still be consolidated by using one cable tray system for all of the power-limited services. Conduit can also be provided from the cable tray to protect critical services. Whatever is decided, with early planning comes the ability to evaluate all the services and consolidate individual voice, data, video, and BAS using a single cable type and pathway, instead of multiple cable types and pathways.



Separate Systems Approach Using Multiple Hardwired Cable Delivery Methods

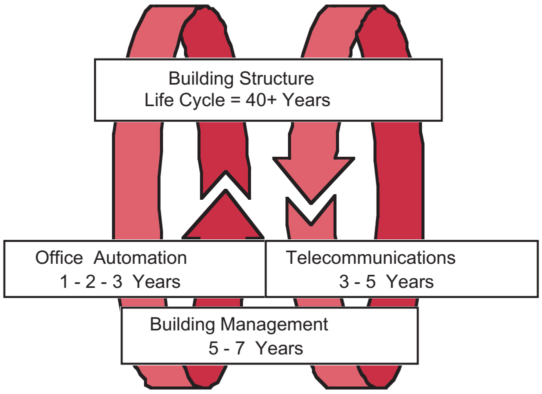


Integrated Systems Approach Using Modular Raceway & Open Office Cabling

The building's tenants can also realize significant savings. A traditional facility with leased space may not provide horizontal cabling for any services. This increases the setup time for tenants. In addition, the tenant usually pays for the voice and data cabling, along with the cost for occupying the space during setup. The cost and setup time for the tenant can be dramatically reduced by installing an open office horizontal cabling grid during the construction phase. Open office cabling, which is actually another term for pre-wired zone cabling, provides a building with a marketable advantage that could mean the difference between empty and occupied space. Attracting tenants with reduced costs and a high-tech platform for services can increase building occupancy, and one month of full occupancy may pay for the entire cabling system.

With open office cabling quickly becoming the preferred method of cabling for both new construction and renovations, it is possible to provide a cabling design without knowing the furniture plan or where any of the devices will be located. The entire design for the cabling can be based on the maximum usage of the size and type of space. As an example, a typical voice and data work area for an office can be located every 9 square meters (100 square feet), and the BAS devices can be calculated based on every 25 square meters (approximately 250 square feet). Using this design approach makes the horizontal cabling and pathways completely reusable for virtually any furniture plan. This is basically the same method used by the electrical industry for power (i.e., lighting and receptacles), except zones are typically called bays and power connections are hardwired.

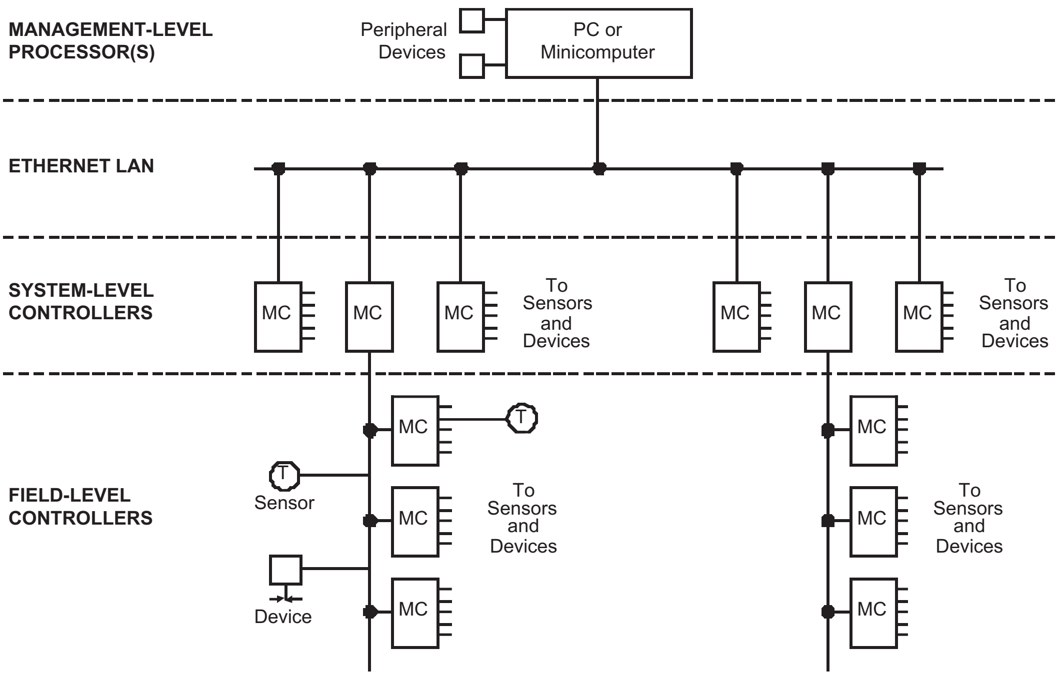
Historically, voice and data horizontal cabling has not been installed during the construction phase. If the cabling is installed during the construction phase it is easier to install, minimizes damage to finished surfaces, and is reusable for the life of the structure when designed properly. Additionally, new cabling does not have to be installed every time the tenants move, or when systems are changed or upgraded. This helps to eliminate cluttered floor and ceiling spaces. In addition, constant rewiring within a structure tends to cause modifications that may affect the physical structure of the building and the integrity of the technology deployed in the structure. As the following "life cycle" diagram shows, systems will change many times during the life of a structure. With proper planning, it is not necessary to provide new cabling every time systems are changed or upgraded.



Flexibility for services (i.e., electrical, voice, data, video, and BAS) is critical for today's business. All services should be considered in the early planning stages when constructing or renovating a building, not just the electrical and BAS, in order to provide cost savings, maximum flexibility, and a platform for high-tech services.

4. Integrating Building Automation Systems (BAS) with the Structured Cabling Systems for Voice and Data

A typical BAS architecture is hierarchical, as shown below, and centralizes the monitoring, operation and management of the modern commercial building. The control functions are usually distributed and resident in the system- and field-level controllers, with higher level functions (e.g., interactions between systems and controllers) resident in the system-level controllers. In addition, each type of controller is usually capable of operating in a stand-alone manner with limited functions in the event of a communications bus failure.



The system-level controllers are used for linking the sequenced operation of field-level controllers, via the communications bus, and will typically have expandable point or port capacity. The field-level controllers are designed for specific application requirements and have limited port capacity. The design of this hierarchical BAS network has been driven by the need to provide limited control functions in the event of a network or communications bus failure (i.e., controllers can operate in a stand-alone mode), and to limit cabling runs from the controllers to the devices. The more controllers you have, the shorter the cabling runs. Since there is no structure to the traditional BAS cabling and all devices are homerun to the controllers, it has always been impractical to homerun cables to a central controller. The traditional BAS cabling method also ties the life cycle of the cabling plant directly to the system to which it is connected.

SCS eliminates this cabling dilemma because of the cabling elements or subsystem approach. Distribution of the cabling takes place in the TR or horizontal terminating point. When looking at the cabling distance from the mechanical area to the device, versus the TR to the device, it's found to be similar since both areas are typically adjacent to each other. What does this mean? Using the dynamic flexibility of the cabling elements (i.e., equipment cabling, cross-connects, etc.) not found in traditional BAS cabling, makes it possible to place the BAS controllers in a variety of configurations to reduce costs and provide greater flexibility.

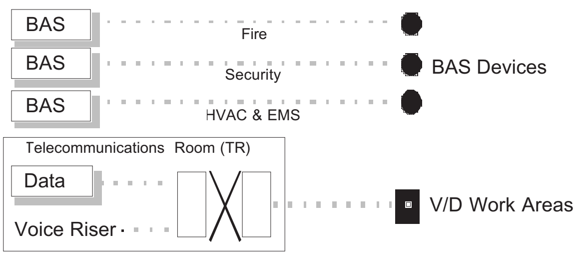
As an example, some field level controllers may be consolidated, depending on their function, and a larger capacity system-level controller can be used to provide BAS connections through the riser cabling to the horizontal, or controllers may be consolidated at the horizontal terminating point. The cabling elements maximize flexibility and can allow any port to be connected to any location in the facility, but will typically add costs to the installation since they are not part of a traditional BAS. However, these costs can be substantially offset by using the cabling elements to consolidate pathways and multiple equipment locations, and by optimizing the telecommunications and BAS installation through the use of a single installation team.

Early planning is critical for determining the optimal placement of the controllers (i.e., distributed, centralized, or a combination of both), telecommunications spaces, and pathways in conjunction with the mechanical/electrical areas. When distributing the BAS controllers the SCS makes it possible to:

- Locate BAS system-level controllers in a mechanical area or the telecommunications spaces (e.g., TC, MC, ER, etc.).
- Reduce the number of BAS system- and field-level controllers by consolidating multiple locations in the TRs or MC.
- Recover from controller failures by retranslating and rerouting BAS services via cross-connects to spare ports.
- Use the TR to create one secure location for housing all the telecommunications and BAS controllers on a floor or floor area.

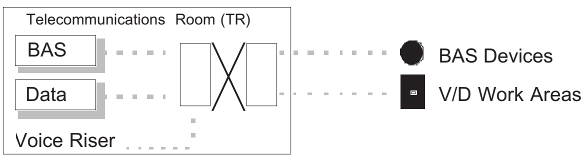
Some BAS vendors state that the controllers must be placed in close proximity to the mechanical equipment for trouble shooting, but an RJ45-type outlet can provide plug-in capabilities for a remote hand held tester. The following illustration, which can still be implemented using the telecommunications distribution system, shows a traditional BAS and telecommunications distribution system using multiple cable types and pathways.

Traditional Distributed BAS - Multiple Horizontal Pathways



The next illustration shows how integrating the telecommunications and BAS with SCS using a distributed BAS equipment approach can consolidate BAS controllers and pathways to reduce costs.

Integrated with Distributed BAS – Single Horizontal Pathways & Common Equipment Location



When distributing, or centralizing the BAS controllers, any power required to operate devices, such as fire alarm strobes or Variable Air Volume (VAV) boxes, can be distributed from the TRs or provided locally. This may necessitate additional BAS hardware (e.g., power supplies) in the TRs since the telecommunications cabling will typically power less devices per cable. However, this situation could be alleviated if BAS power supplies were manufactured with more power taps that supplied less current per tap (e.g., 10 outputs that deliver up to 1 amp per tap). The power taps could even be modular, with multiple appearances on a jack, which would also simplify the installation.

In addition to being distributed, the BAS controllers can also be centralized if distance limitations are supported. A centralized equipment approach does not mean centralized intelligence since most modern BAS use distributed intelligence (i.e. small capacity controllers distributed through a building), but distributed intelligence can still be accomplished using a centralized equipment approach. This approach works best with system-level controllers incorporating a minimum of 32 ports. Large capacity system-level controllers may not be available through some BAS vendors, but this strategy can still be accomplished using smaller sized controllers.

Centralizing the BAS controllers can be compared to some of today's telecommunications strategies, including:

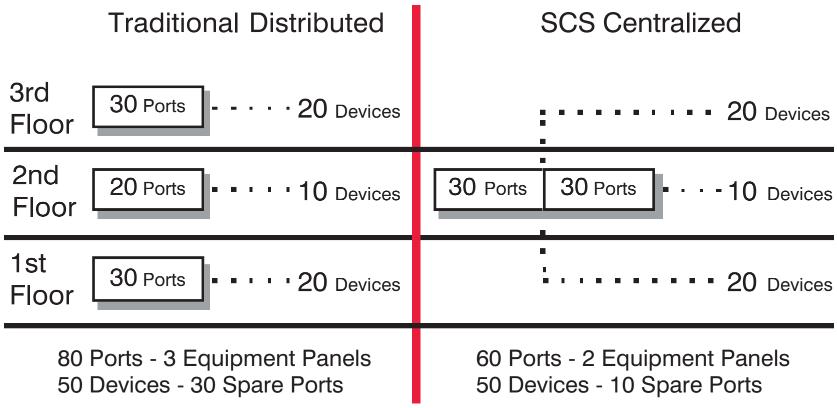
A private branch exchange (PBX) distributed (i.e., remote PBX cabinets) to meet distance requirements, otherwise it is centralized to reduce equipment costs.

- Centralized fiber administration is used to reduce the cost of active electronics.
- Data hubs are only distributed to maintain distances limitations, otherwise they would be centralized to reduce the cost of active electronics.

Using a distributed equipment approach is typically not cost effective for most types of equipment or systems. Sometimes the system limitations for data transmission or power require a distributed topology, but this is usually not the case for the typical low-speed and power-limited BAS equipment. Because the traditional BAS installation has no cross-connect system, it is neither practical nor cost effective to run device cables to a central equipment location. When centralizing the BAS controllers the SCS makes it possible to:

- Use all the available BAS ports anywhere in the building via the riser backbone cabling.
- Reduce the number of system- and field-level controllers.
- Provide centralized BAS administration.
- Recover from equipment failures by retranslating and rerouting BAS services via cross-connects to spare ports. (i.e., in a traditional installation, the panel or components within the controller would have to be replaced in order to restore service).
- Alternate ports from controllers to eliminate complete outages in designated areas.
- Reduce BAS installation, testing, equipment, and electrical costs by consolidating equipment areas.

The following illustration shows how centralizing the BAS equipment can reduce the quantity and associated costs of the BAS controllers.



The telecommunications cabling also makes upgrading the BAS controllers faster and more cost effective. In a traditional installation, devices are wired straight from the controller to the device. When the controller needs to be upgraded, the cables must be reterminated or the terminal strips need to be moved to the new controller. This is not always easy or practical. In some cases the device cables may not be reusable. However, the SCS cabling elements allow the devices to be reconfigured at the cross-connect location with the simple addition of some new equipment cabling. The SCS approach assures economical equipment upgrades with minimal service outages.

Speeds for data transmission are rising as technology advances and more information is processed. The new BAS are composed of intelligent controllers with addressable devices, and basically mirror today's data networking and LAN architectures. In fact, data backbones are increasingly being used as a traffic mechanism for the BAS communications. This allows any PC with the proper passwords to access the BAS via an internal network or even through the Internet. As the BAS equipment becomes more advanced, their associated data transmission speeds will also increase. Currently, some of the traditional BAS cabling will only support limited data rates and applications. If the right cabling is not incorporated into the structure during construction, it may require new cabling at a future point in time.

5. Bid Specifications

Systems integration can easily be accomplished with the proper bid specifications and a decision by the building owner, developer or executive management to select the cabling system first. Each individual equipment specification should provide, or refer to, an overview of the systems integration concept and define the scope of work responsibilities by SCS subsystem for the equipment vendor and cabling contractor. The electrical characteristics of the cabling should also be included in the specification to assure systems performance.

Once this has been provided, a bid specification for the cabling and pathways can be defined to integrate all the systems. By using this systems integration approach it is possible to reduce each equipment vendor's bid by 20-30% since cabling, pathways, and cable path engineering will be provided by an integrated cabling specification.

6. Conclusion

The recent publication of ANSI/TIA/EIA-862 Building Automation Cabling Standard will encourage the use of structured cabling to support building services. The SCS concept provides many benefits, resulting in minimizing the total cost of ownership (TCO) and maximizing the return on investment (ROI) of a building property.

Construction costs for the cabling of the voice, data, and BAS can be reduced by up to 30% when integrating the cabling and pathways. One project team can engineer, install, and project manage the installation for all the cabling. Trade contention is reduced, scheduling is easier, and ultimately the project runs more efficiently. If something goes wrong, the customer only has to deal with one team for systems integration. The length of the overall project for engineering and installation can also be reduced by consolidating the cabling installation.

The key to this is **early planning.** If the systems (Voice, Data, Fire, Security, HVAC, etc.) are bid and designed separately, costs for delivering the cable will increase and flexibility will decrease. Costs can be minimized and flexibility can be increased if pathways are shared for the various services. How the cabling is delivered to the work areas and devices will ultimately determine the cost of changes and rearrangements. One integrated cabling system and cable pathway can be implemented, versus five or six individual cabling systems and pathways.

Moves, changes, rearrangements, and upgrades can be performed more cost effectively, with a potential savings of 25 - 40% for material and labor when using an open office cabling approach. There is less disruption to the work environment, which also affects the cost and performance of doing business. In addition, with only one cabling system to administer, the response time to end-user cabling requests is reduced. This also reduces the time required to maintain the cabling system. How the “building is built” today will ultimately determine how much it costs to live there tomorrow.

7. Cost Models

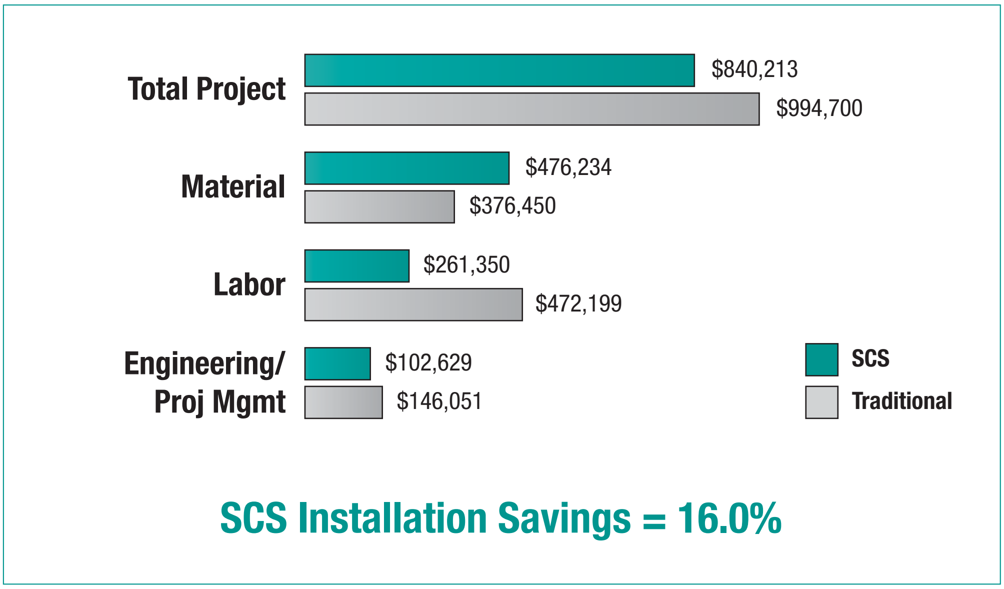
Overview and Premises Configuration

This cost model compares a traditional separate systems installation to a singly designed and installed Structured Cabling System (SCS). The approach can be applied to any new or renovated building project. In this case, the traditional approach uses multiple cable types and pathways. The SCS method uses the same cable type for all the voice, data, video and BAS services, with a common pathway for all horizontal low and high voltage services. The SCS “Open Office” cabling approach also provides for additional horizontal coverage with 306 spare outlets.

Premises Configuration	Separate Traditional	Integrated SCS
Floors	5	5
Square Feet	100,000	100,000
Square Meters	9,294	9,294
Horizontal Cabling	Homerun	Open Office
Horizontal Pathway	Conduit/Tray	Raceway
Work Areas	850	850
Voice/Data Outlets	2550	2550
Spare Outlets (*)	0	306
BAS Devices	400	400
Electric Circuits	257	257

Installation Costs

In this configuration, the installation cost comparison uses typical pricing from the United States for labor, material and engineering. Although the pricing for these items may vary, particularly outside of the United States, the concept can be applied to projects anywhere. The SCS savings is basically achieved by designing and installing a single integrated cabling system versus multiple cabling systems and pathways. In addition, by centralizing the BAS equipment using the SCS subsystem approach, there is also a savings associated with reducing the quantity of controllers.

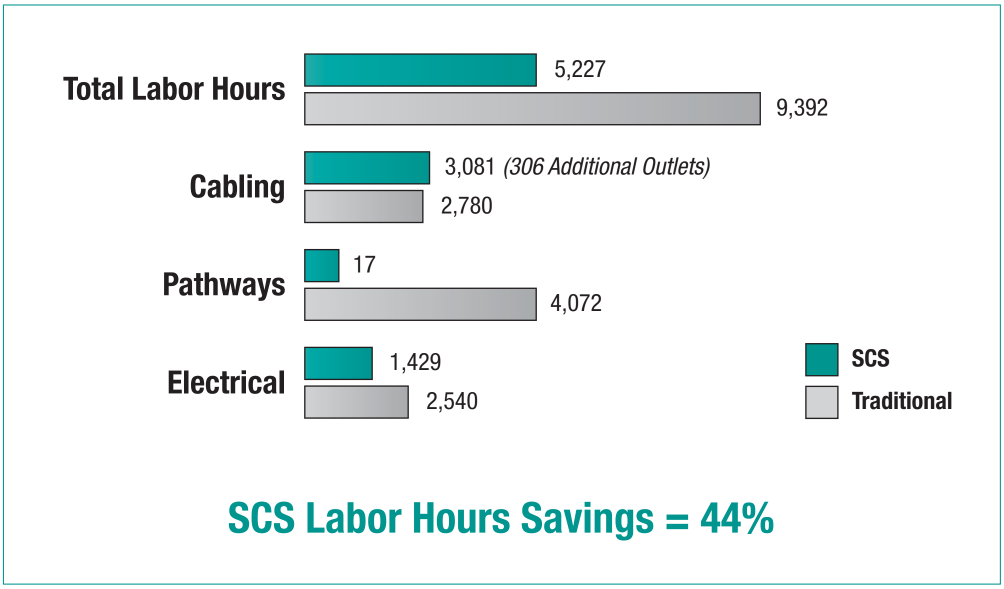


Installation Costs	Separate Traditional	Integrated SCS
Material - Voice/Data/BAS Cabling	$252,136	$298,545
Labor - Voice/Data/BAS Cabling	$139,031	$154,050
Material - Conduit/Tray vs. Raceway	$79,472	$82,508
Labor - Conduit/Tray vs. Raceway	$203,637	$35,850
Material - Electrical (Horizontal)	$41,232	$95,181
Labor - Electrical (Horizontal)	$129,531	$71,450
Additional BAS Equipment Panels	$3,610	
Engineering and Consultation	$63,251	$51,329
Project Management	$82,800	$51,300
Total Installation Cost	**$994,700**	**$840,213**
SCS Installation Saving = 16%		**$154,487**

Installation Labor Hours

The integrated approach, in this example, dramatically reduces the labor hours and actually takes about half the time to implement when compared to the traditional methods. The primary labor savings comes from consolidating the horizontal cable pathways and providing modular electrical services.

The hours for the distribution cabling are relatively close, but the SCS approach has 306 additional outlets. More cables can be installed for about the same amount of labor because the open office cabling approach consolidates the number of cables pulled together. In addition, all voice, data, video, and BAS cables are installed concurrently. By reducing the labor hours, the space can typically be occupied at an earlier date.



Labor Hours for Installation	Separate Traditional	Integrated SCS
Labor - Voice/Data/BAS Cabling	2,780 Hours	3,081 Hours
Labor - Pathways Conduit/Tray vs. Raceway	4,072 Hours	717 Hours
Labor - Electrical (Horizontal)	2,540 Hours	1,429 Hours
Total Labor Hours	**9,392 Hours**	**5,227 Hours**
SCS Labor Savings = 44%		**4,165 Hours**

Move, Add, Change (MAC) Costs

In addition to examining the construction costs it is important to also evaluate the operational costs associated with the moves, adds, and changes (MACs) of the voice, data, and electrical services. The costs depicted in this example are based on typical United States labor rates for the actual work to be accomplished and do not include visit charges. The comparison assumes that 15% of the work areas will be new, and the remaining 85% will be rearranged or reused. One work area consists of a voice, two data, and dual electrical outlet.

If 50% of the work areas experience these MACs (churn) over a one-year period, the SCS operational savings amount to 39%. When projected over a five year period the savings are not only substantial, but allow the building owner or manager to quickly respond to changes requested by the occupants.

SCS Move, Add, Change (MAC) Savings = 39% Per Year

MAC Costs Per Work Area	Separate Traditional	Integrated SCS SCS Open Office	Savings
Cost Per Move (60% of MACs)	$115	$61	$54
Cost Per Add (15% of MACs)	$421	$232	$189
Cost Per Change (25% of MACs)	$38	$38	
MAC Per Year = 50% of Work Area 5-Year MAC Costs SCS MAC Savings = 39% Per Year	**$334,267**	**$205,229**	**$129,038**

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