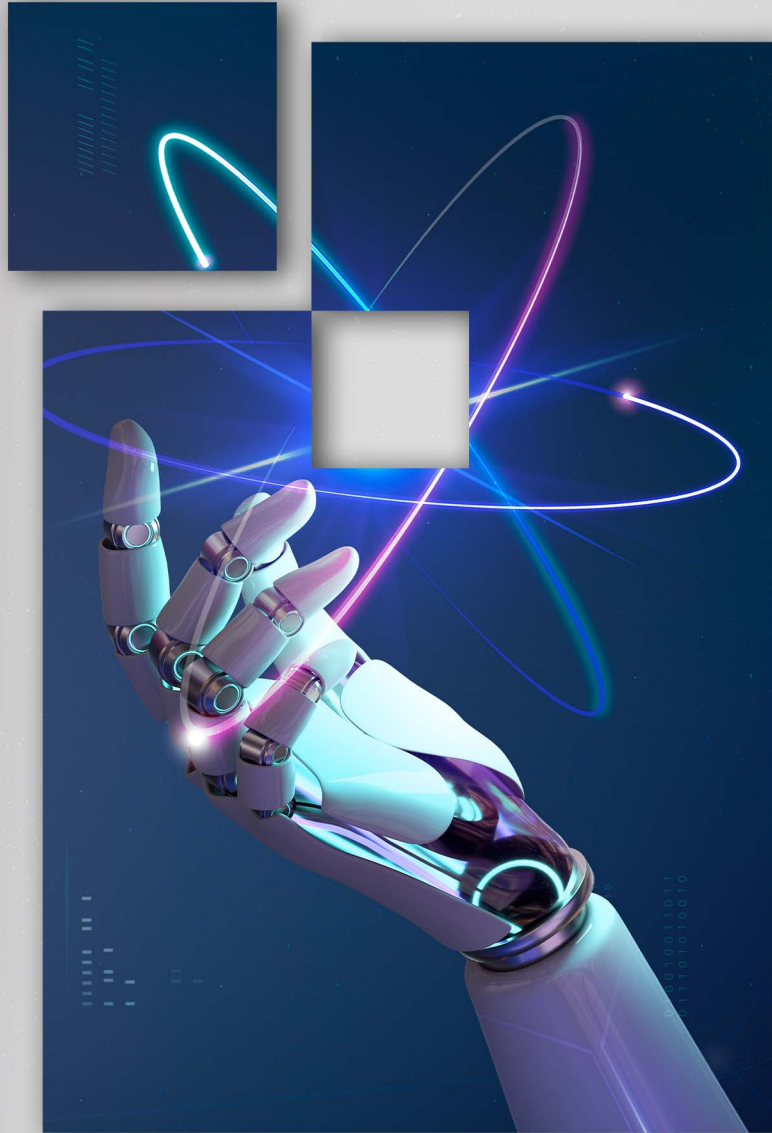


Facility Information Management & Technology Management



Facility managers must excel in technology. This includes monitoring technology trends, conducting assessments for improvements, aligning facility tech with organizational IT, assessing tech application in operations, and implementing integrated workplace management systems.



IFMA Facility Management Learning System

Book 6

Contents

Technology

Introduction	6-1
Chapter 1: Strategic Alignment of Facility Technology	6-6
Topic 1: Using Technology to Support Strategy	6-6
Topic 2: Current Trends in Organizations and Technology	6-10
Topic 3: Using Technology to Meet Stakeholder Needs	6-22
Chapter 2: Control and Integration Systems.....	6-32
Topic 1: Building Technology	6-32
Topic 2: Building Automation Systems (BAS)	6-37
Topic 3: Energy Management Systems (EMS).....	6-44
Topic 4: Integrated Workplace Management Systems	6-48
Chapter 3: Emerging and Evolving Facility Technology.....	6-65
Topic 1: Building Information Modeling.....	6-65
Topic 2: Building Imaging Technology	6-73
Topic 3: Geospatial Information Systems.....	6-75
Topic 4: Automatic Identification and Data Capture	6-80
Chapter 4: Communication Technology	6-90
Topic 1: Facility Voice and Data Communication	6-90
Topic 2: Managing ICT Systems	6-93
Topic 3: Optimizing Facility Communication Technology	6-95
Chapter 5: Workplace Technology	6-104
Topic 1: Supporting Workplace Innovation.....	6-104
Topic 2: Supporting Workplace Mobility	6-106
Chapter 6: Implementing Technology Projects.....	6-111
Topic 1: Optimizing Facility Technology Projects.....	6-111
Topic 2: Project Analysis and Implementation.....	6-115
Cumulative Course Bibliography.....	6-131
Cumulative Course Index.....	6-162



The references in this course have been selected solely on the basis of their educational value to the IFMA Facility Management Learning System and on the content of the material. IFMA does not endorse any services or other materials that may be offered or recommended by the authors or publishers of the books and publications listed in this course.

Every effort has been made to ensure that all information is current and correct. However, laws and regulations are constantly changing. Therefore, this program is distributed with the understanding that the publisher and authors are not offering legal or professional services.

Acknowledgments

We would like to thank the following dedicated subject matter experts (SMEs) who shared their time, experience and insights during the development of the IFMA Facility Management Learning System.

Content Development SMEs

Stephen Brown, CFM, FMP, CPE, CBCP, REM	Kirt Miller, FMP, CFM, IFMA Fellow
Dean Hitchcock, Lieutenant Colonel, USAF, CFM	John Parsons, CFM
Joachim Hohmann, Ph.D., MSc, MBA, CFM	Teena G. Shouse, CFM, IFMA Fellow
David L. King, AIA, CFM, SFP, LEED AP	David L. Teska, MS, MPCP
Robert Kleimenhagen, Jr., CFM	Kate Thibeault, CFM, ABCP
Louis Liu	

Content Analysis SMEs

Dr. Doug Aldrich, CFM, IFMA Fellow	Erik A. Johansson, CFM, FMA
Jeff Allcroft, CFM, SFP, LEED Green Associate	Lawrence G. Kownacki, CFM
Becky Beilharz, CFM	Maja MacDougall
Sean N. Bondar, CFM	Peggy A. McCarthy, CFM, IFMA Fellow
Evelyn Braie, CFM, CFMJ, ACIPM	Tony Miele, CFM, FMP
William D. Broome, CFM, SFP, LEED Green Associate	Patricia A. Moonier, CFM, FMP, SFP
CHAN Kwong Fuk Wilson	Patrick H. Okamura, CFM, SFP, FMP, CSS, CIAQM, LEED BD&C, IFMA Fellow
Jack Christensen, CFM, REP	Anthony Pizzitola, MBA, CFM, CBCP, MBCI
William T. Conley, CFM, IFMA Fellow	Larry E. Rust, CFM
Gerard DiCola, CFM, FMP, LEED Green Associate	Ronald V. Sachse, PMP, CFM, SFP, FMP
Joseph M. Drew, CFM, PMP, SFP	Mark R. Sekula, FMP, CFM, LEED AP, IFMA Fellow
Howard “Buck” Fisher, CFM, LEED Green Associate	Erik Selvig, CFM, LEED AP ID+C, CSBA
Patricia Galley, CFM	Mary L. Speed-Perri, MBA, CFM
Victoria Hardy, CFM, CFMJ	Meredith Thatcher, CFM, IFMA Fellow, LEED AP
Christopher P. Hodges, P.E., CFM, LEED AP, IFMA Fellow, FRICS	Ryan Thompson, CFM, CMRP, MMP, ALB
John Huffman, CFM, FMA	Kit Tuveson, CFM, SFP, IFMA Fellow
	Fred Weiss, CFM, IFMA Fellow
	Dave Wilson, CFM, PGDipMgt, MBIFM



Technology

✦ Introduction

Role of facility managers as related to *Technology* competency

The *Technology* section of the IFMA global job task analysis states that a competent facility manager should be able to:

- Monitor and evaluate technology trends and innovation.
- Conduct assessments and/or collaborate on facility management technology needs analysis in order to recommend technology improvements.
- Align facility management technology with organizational information technology.
- Assess the application of technology within facility operations.
- Evaluate, implement and operate integrated workplace management systems (IWMS).

Technology and the facility manager

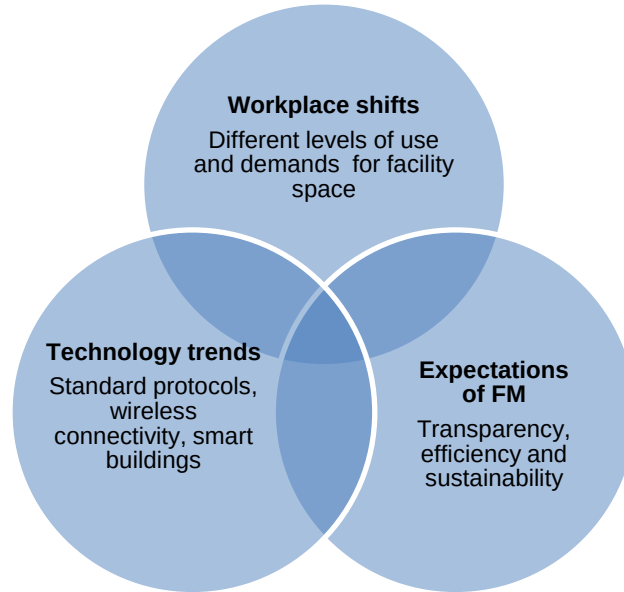
There was a time when “technology” for a facility manager meant wrenches, ladders and flashlights. The change in facility technology has been fast and ceaseless. In 1965 Intel co-founder Howard Moore noted that the number of components in an integrated circuit had doubled every year since 1958 and would probably continue to grow exponentially until 1975. (This observation itself evolved quickly into Moore’s Law, a mathematical projection about the pace of innovation.) The growth trend lasted well into the 21st century, a bit longer than Moore anticipated.

Today some of the most essential tools for a facility manager are digital. The growth in processing power has enabled facility managers to gather, store and analyze enormous quantities of facility performance data and to act on that data quickly—in some instances, automatically.

As Exhibit 6-1 indicates, an effective use of new facility management technology may be the key to meeting the changing needs of workplaces and occupants and the changing expectations of the FM’s organization.



Exhibit 6-1: Technology's Role in Meeting New Workplace and Organizational Needs



The *Technology* competency focuses on the ways in which facility managers can use technology to meet the expectations of management and the changing needs of occupants.

- **What organizations today expect from facility managers.** Facility managers work today in an age driven by “big data” that allows senior management to see exactly how their organizations are performing in terms of efficiency, productivity and sustainability. The right technology, effectively implemented, can increase the value of the organization’s assets. For example, systems that support high levels of sustainable operation and demonstrate performance with reliable data are more desirable properties, commanding higher leases and achieving higher occupancy rates. Facility technology can also be aligned with the organization’s overall strategic goals and support progress toward its objectives. For example, it may be the key to optimizing facility size, decreasing operating costs and improving cash flow. Today, facility managers must see facility operations and technology from the perspective of the organization’s senior managers. That means not collecting pointless data and helping organization leaders understand the implications of building performance data so that they can make better decisions.



- **What occupants and organizations expect from the workplace.** Some needs haven't changed. Occupants still expect a comfortable, clean, safe and secure place to work. But mobility and social changes have redefined what constitutes a workplace, and occupants expect the same flexibility and customization that they can get in other parts of their lives. Organizational silos are breaking down as collaboration and project-focused teams become more essential to innovation and marketplace agility.
- **What technology can do to help meet these needs.** Trends in new technology toward standardization and connectivity between applications support integrated workflow management and automated building control. New communications technology supports face-to-face meetings, information sharing and mobility efficiently and securely. By putting more knowledge—and more integrated knowledge—about every aspect of a building at a facility manager's fingertips, emerging technologies can help facilities support goals related to productivity, safety, security and sustainability and achieve compliance with standards and regulations.

Scope of Technology competency

This competency provides a starting point for facility managers' continuing education in technology. It is not intended as an in-depth review of underlying technologies and available products. It assumes a basic understanding of computing terminology and concepts—such as networks, the Internet, user interfaces and security devices. It also maintains a facility manager's perspective on technology, focusing on a level of detail that will support helpful dialogue with members of the organization's information technology (IT) function and with vendors. It is not intended to make facility managers experts in advanced building technology or information technology.

It is not practical for most facility managers to try to acquire a level of expertise that is already available in their organization's IT function or through professionals and consultants in building and communications technologies. The competency's goal is to help facility managers talk intelligently with their technology partners, to know what questions to ask and what information to provide, to make intelligent purchasing decisions, and to manage implementation and operation of new technology effectively.

Another reason not to dive into the details of the technologies described in this competency is the rate of technological change. Because technology is constantly evolving, the technologies and products mentioned in this competency may persist, or evolve into different forms, or disappear entirely.



This is why the competency is reviewed and updated regularly. So, rather than providing a detailed grounding in how today's building technology works, the competency focuses on probable trends and capabilities in building technology—on how building technology can help facility managers fulfill their own strategic objectives and support the organization's strategic plan. While they may not be technical experts, facility managers should be aware of what technology may be able to do for their facilities and organizations.

The fact is that to maintain true technology competency, facility managers must commit to continuous learning. They must look in an active and ongoing manner for opportunities to add depth and currency to their understanding of building technologies. They can do this by attending professional meetings and following facility management publications.

Overview of Technology competency

Technology is, of course, a broad topic. Learners will find references to technology from different perspectives in other competencies in this program—for example, to sustainable technologies in the *Environmental Stewardship and Sustainability* competency or to safety and security technologies in the *Emergency Preparedness and Business Continuity* competency. The *Technology* competency focuses specifically on advanced facility technology and the process of ensuring that chosen technologies meet the current and future needs of the organization, are properly implemented, and are used in the most effective manner. Exhibit 6-2 describes the content covered in the following chapters.

Exhibit 6-2: Overview of Technology Competency (continued on next page)

Chapter	Content
1. Strategic Alignment of Facility Technology	- Review of the principles of strategic management and the alignment of the facility technology plan with the organization's overall goals and objectives - Stakeholder needs as they apply to facility technology - Relationship between facility management and IT
2. Control and Integration Systems	Overview of the capabilities and benefits of: - Building automation system (BAS) - Energy management system (EMS) - Integrated workplace management system (IWMS), which can include special purpose systems, such as space, asset, maintenance and project management



Exhibit 6-2: Overview of *Technology Competency* (concluded)

Chapter	Content
3. Emerging and Evolving Facility Technology	Overview of the capabilities and advantages of: • Building information modeling (BIM) • Building imaging technologies such as laser and thermal scanning • Geospatial information system (GIS) • Automatic identification systems, such as bar coding and radio frequency identification (RFID)
4. Communication Technology	• How wireless technology has affected facility communication networks • Supporting mobile communication devices in the facility • Emergent communication technologies, such as Voice over Internet Protocol (VoIP)
5. Workplace Technology	Strategies to support: • Collaboration and productivity, including “smart” rooms and virtual meeting technology • Flexible and productive use of workspace
6. Implementing Technology Projects	Reviewing project management steps as applied to the special requirements of a technology project, including: • Conducting technology needs assessments • Selecting cost-effective solutions • Planning, monitoring and documenting project output • Testing for quality and alignment with project objectives • Implementing the switchover and training users • Evaluating and communicating project results



Chapter 1: Strategic Alignment of Facility Technology

After completing this chapter, students will be able to:

- Illustrate alignment of the facility's use of technology with the organization's strategic plan.
 - Provide examples of trends in organizations and workplaces that affect a facility manager's use of technology.
 - Distinguish different stakeholder needs and expectations and their implications for facility technology use.
-

✦ Topic 1: Using Technology to Support Strategy

Strategic facility plan and technology

The facility's use of technology must be seen in the context of the organization's and FM's strategic plans. Technology is a tool that can perform certain tasks, but it should also be seen as the means for aligning those plans and helping both the organization and FM achieve its long-range strategic objectives.

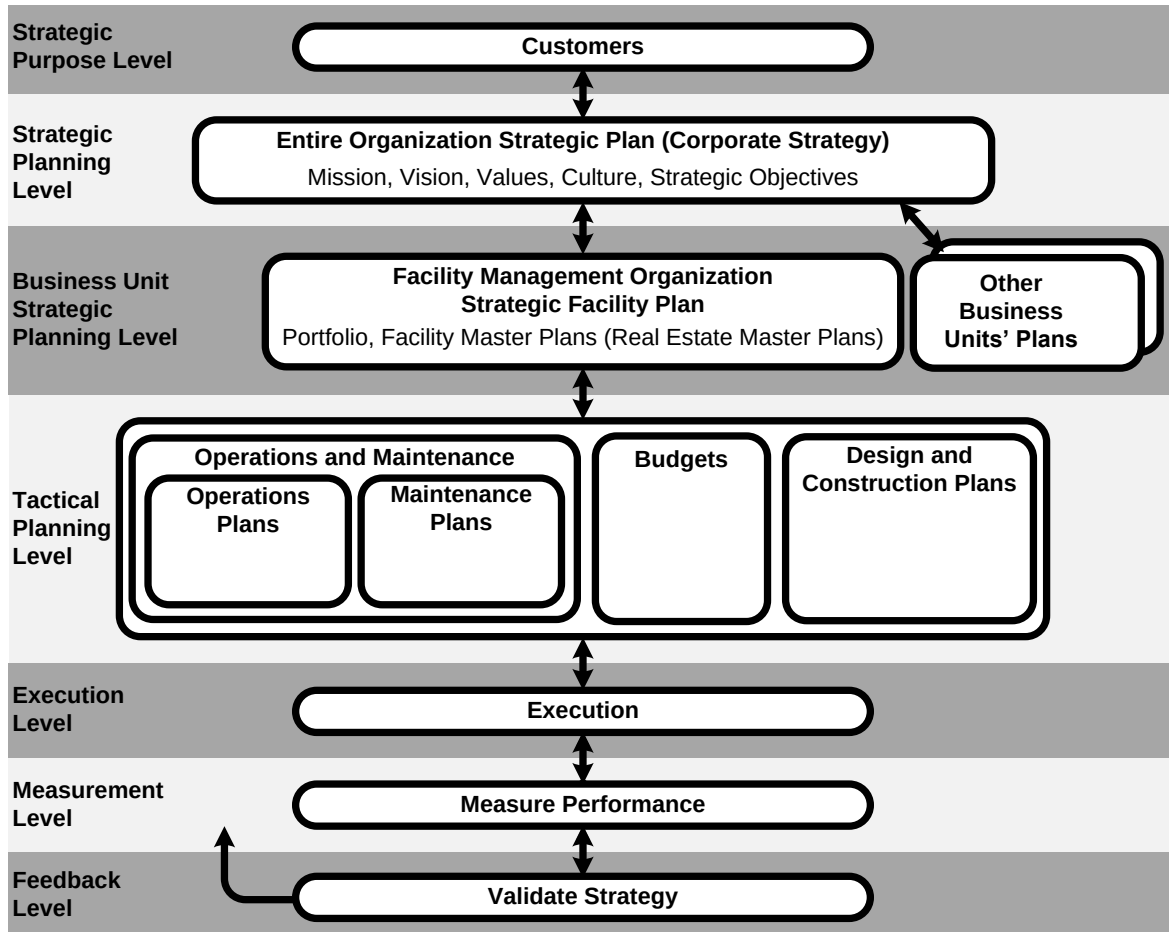
The *Leadership and Strategy* competency describes the process a well-managed organization uses to set its strategic objectives. This process is illustrated in Exhibit 6-3 on the next page.

The model underscores the relationship between the organization's strategic plan and the strategic facility plan. The organization seeks first to understand the needs of its customers and then plans a strategy to fill those needs in a way that fits the organization's mission, values and culture. The various members of the organization—its business units—are called upon to create their own strategic plans to support the organization's strategic objectives. Each business unit, including facility management, must decide how it will use its resources to support and advance the organization's overall agenda. Will it need to shift resources from previous areas of focus to new objectives? Will it need to increase productivity? How will it do this? Are new kinds of skilled employees needed? Will new tools be needed? Should we organize ourselves differently?

The answer to these questions becomes the strategic facility plan, which is itself composed of multiple tactical plans. These tactical plans can include budgeting and staffing plans, operating and maintenance plans, capital projects and technology plans.



Exhibit 6-3: Strategic Planning Overview Model



Benefits of technology to the organization

Facility managers must be prepared to present the benefits of adopting and implementing new facility technology and to evaluate investments in technology in strategic terms, which may be financial or non-financial.

The benefits of advanced building technologies include the following:

- Cost savings from:
 - Improved operating efficiency
 - Longer equipment life from improved maintenance practices
 - Optimized use of facility space
 - Efficient vendor relations and project management
- Alignment with organizational values, such as a commitment to sustainable practices, improved work/life balance and equipping employees with quality tools



- Improved organizational governance. There is greater control over organizational assets and greater transparency in the results of operating and purchasing decisions. (Keep in mind that greater transparency can also mean greater accountability. For that reason, some members of the organization may be reluctant to adopt technology that more clearly documents returns on investment.)
- Enhanced workplace quality and services that can also increase facility customer satisfaction
- Documenting compliance with laws, regulations and contracts
- Knowledge management. A continual challenge for organizations is to capture and access the collective wisdom of its members, even as members exit the organization. Facility technology provides the means to gather information about the facility's systems and practices over time and to organize it and make it easily accessible to both new and old members of the organization.

How organizational strategy can affect facility technology projects

A shift in organizational strategy can create the need for enhanced use of technology within a facility. Consider the following examples:

- A property management company decides that, to reach its financial performance goals, it will target a specific type of tenant—organizations that will be willing to pay higher rents for features that can help them attract and retain knowledge workers. To support this strategy, facility management asks senior management to invest in technology improvements and sustainable programs for new and existing properties, possibly seeking sustainable building certification when feasible. Facility management will need to acquire building automation technology to optimize energy use. An integrated workplace management system (IWMS) could be used to generate reports to support certification applications. The facility management organization will also need to ensure that its staff is trained in the use of the new technology.
- A health-care company that includes a hospital and several office buildings must become more efficient. Management sees an opportunity for growth in this market, and would like to increase overall revenues by 10 percent. At the same time, budgets are being cut because of aggressive negotiations by government payers and insurers. Facility management has been told to decrease facility space. Facility management considers this strategic direction and proposes more



aggressive space management and the use of an analytic tool that will help facility management measure the use of facility space in terms of productivity. The goal is to redefine space to support revenue-producing activities and, if possible, to decrease the organization's physical footprint. One opportunity may be the significant space consumed for record keeping. Working with IT, facility management may be able to repurpose that space by using newer technologies that allow offsite storage and more rapid, global access.

- A manufacturer focuses on contracts with a few, very large customers. While this provides stable revenue and lower administrative and selling costs, it means that the company has a very low tolerance for risks that can threaten contracted commitments to deliver product in specific quantities at set times. Facility management considers this situation and proposes using a building automation system (BAS) that can provide early warnings of core building system failures, such as loss of air conditioning, which might inhibit occupant activity. An integrated maintenance workflow system can also be used to implement a more systematic approach to maintaining building systems.

These are only a few examples. Every organization will have its unique challenges, and it falls to facility management professionals to develop creative ways to meet those challenges—ways that increasingly involve technology.

Effective facility technology plans

Facility managers should remember the goal of strategic alignment when they propose a technology project to management. They should be prepared to demonstrate how the new or enhanced capabilities are aligned with the organization's strategy and will promote organizational objectives. Alignment can be strengthened when facility managers integrate facility technology with the organization's existing platform technology. For example, they should consider implementation of modules of the corporate enterprise resource planning (ERP) system. ERP products integrate internal and external data across an organization, not solely within specific functions, to perform a variety of organizational functions, such as accounting and customer relationship management. This allows users in different functions to share common information for different purposes. For example, FM can use real estate, asset management and maintenance management modules to integrate procurement and fiscal reporting.



In addition, a good technology plan:

- Emphasizes benefits to the organization first and then describes the technology, limiting details to the audience's interest and level of understanding.
- Is based on a needs assessment. Technology needs assessments are discussed in Chapter 6, "Implementing Technology Projects."
- Is created in collaboration with the organization's IT function to ensure compliance with internal standards, facilitate adoption and installation and avoid software and system conflicts.
- Considers the impact of the plan on people (both occupants and staff) and on processes.
- Includes metrics against which the success of the plan can be assessed.
- Is benchmarked against best practices in comparable organizations or facilities.
- Includes a business case that demonstrates the project's economic advantages and discusses non-economic advantages. Economic analyses may include tools such as return on investment (ROI), life-cycle cost analysis (LCCA) or total cost of ownership (TCO). These tools are discussed in the *Operations and Maintenance* competency.
- Considers the pace of technological change in the context of the project time table. The fast pace of change brings both opportunities for technology users and headaches for decision makers. Desk drawers and filing cabinets and even facility plenums are full of the remnants of old technology. How many people use thumb or flash drives now, when they can more easily access or share necessary information through the Internet? How many facility vehicles have GPS that is duplicated on their drivers' smartphones? Timelines for lengthy projects must anticipate the potential for new versions of software with different capabilities and requirements.

Topic 2: Current Trends in Organizations and Technology

There are many observations to be made about technology, but here are three safe ones:

- Technology makes change—sometimes better, sometimes worse, often just different.
- Technology itself will change—as noted above, constantly evolving and requiring continual reassessment of its uses.
- Technology can help organizations and occupants to adapt to change—to respond to changes in society, the global marketplace and organizational practices.



The key word here is change. Competent facility managers learn to accept and master change, whether it is occurring in their facility management tools or in the facility itself. One of the first steps to mastering change is to maintain a general awareness of trends and innovations, in both the field of technology and in organizations and workplaces. Facility managers can increase their understanding of facility technology trends and innovations through participating in professional associations, attending meetings and networking with their peers.

Organizational trends

As shown in Exhibit 6-4, organizations, occupants and the workplace have been influenced by changes in a number of areas, including:

- Globalization.
- More intense economic competition.
- Increase in knowledge workers.
- A growing interest in and commitment to sustainable organizational practices.
- Demography and workplaces.

Many of these changes are supported by changes in technology.

Exhibit 6-4: Organizational Trends Affecting Facility Management



Globalization

The world is moving from an age of colonialism into what the U.S. journalist Thomas Friedman calls a flat world—a global economy in which the “playing field” has been leveled. Because of changes in transportation, communication and technology, relatively young economies can compete effectively with matured economies. North America and Europe must share markets with the BRIC nations—Brazil, Russia, India and China—and other new players.

Globalization has given rise to the development of business organizations that are not simply international (doing business across borders) or multinational (headquartered in one country but having production and marketing interests in many countries). These new organizations are transnational entities, often developing a global template that can be adapted to local markets.

The lifeblood of a transnational organization is communication. Teams span continents and time zones. Communication and work proceeds 24 hours a day, seven days a week. Flexibility, sharing and openness to new ideas are more important values than empire building and protection.

Intense economic competition

Globalization and new technologies have intensified competition for markets. New supply chain practices, outsourcing, offshoring and virtual retailing have helped businesses lower costs and, consequently, prices. However, profit margins are more fragile.

The trend now in strategic business management is toward leaner operations and higher productivity, reliability and quality. Business interruptions or conditions that reduce productivity in general erode profitability. The same can be said for square footage that is not put to use in the most productive manner. In general, facilities are becoming more compact. Management must also be able to track and report economic performance and use accurate, timely data to make business decisions.

Knowledge workers

While manufacturing is still essential, an increasing amount of capital is invested in activities that require highly skilled, knowledgeable workers. Instant access to colleagues, institutional wisdom and experience, data and tools is essential. These workers take time to develop and are not easily replaced. Organizations spend more time now trying to attract and retain these high-value workers—trying to create positive employer branding.



The employer brand is affected by diverse factors, such as:

- Policies regarding flexible work hours and better work/life balance.
- Competitive compensation systems.
- Access to career building opportunities and new tools.
- Facility surroundings that support their work habits and social needs.

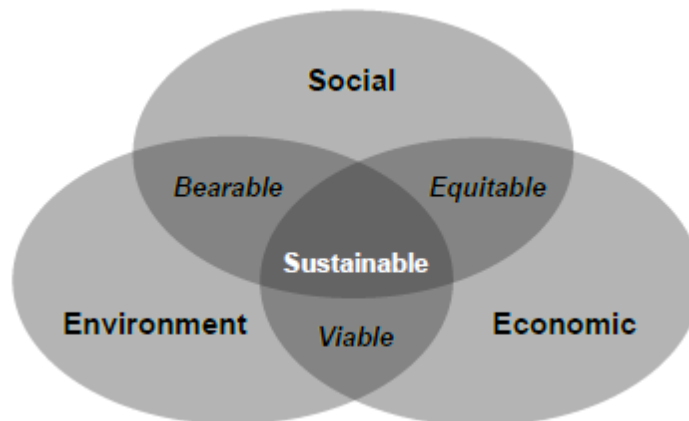
Sustainable organizations and practices

One of the elements of employer branding may be an organization's values, as evidenced in its commitment to sustainable policies and practices. A sustainable organization has committed to practices that support rather than deplete finite resources. An interest in sustainability may come from factors other than organizational values, however. Sustainable practices may be required by an organization's clients and customers, government agencies and regulators and the organization's bottom line.

Competition for finite resources is increasing. Governments are imposing carbon taxes to impel changes in energy use and pay for mitigating the effects of climate change. An organization that can manage its materials and energy use can be more competitive. It can also seek sustainable building certification voluntarily. These buildings can provide greater savings and occupant comfort, but can also strengthen the organization's public image and increase the property's desirability to tenants.

The Triple Bottom Line, shown in Exhibit 6-5, illustrates sustainable facilities as an intersection of social, environmental and economic forces that call for solutions that are bearable, equitable and viable. The *Environmental Stewardship and Sustainability* competency explores the strategic issues surrounding sustainable facility management.

Exhibit 6-5: The Triple Bottom Line



Demographic and workplace trends

Workplaces have become extremely diverse. Although there may be geographical and industry exceptions, men and women are equally represented. The age range of workers has increased, and each age group has its own cultural preferences and needs. For example, younger employees require digital accessibility, while some older workers may require training and support to get the full benefit of workplace technology. Younger workers may also have different ways of working now, needing connectivity outside the office and ways to collaborate online with associates.

Security has become a growing issue. Acts of violence can come from the outside (e.g., terrorism) or the inside (e.g., workplace violence). The critical nature of proprietary knowledge makes an organization more vulnerable to theft and sabotage, including breaches of cyber security through hacking, thefts of service or the introduction of viruses that can corrupt data and terminate functions.

Although its demise was predicted, the office has not disappeared. The type of work done there has changed, however. Because of technology, solo or independent work may be done anywhere—home, hotel rooms, coffee shops. The workplace has now become a place to reconnect periodically and to collaborate. Meeting space is more productive for the organization than large corporate suites.

Technology trends

If one stands back and observes the new technology from a distance, certain vividly colored threads begin to stand out. These trends are directly influencing the way technology is used in the workplace and by facility management. They include, as shown in Exhibit 6-6 on the next page:

- Embedding of more data and greater intelligence in information systems.
- Greater interoperability among building control systems.
- Virtualization of data storage, access and computing power.
- Access.
- Enhanced communication.

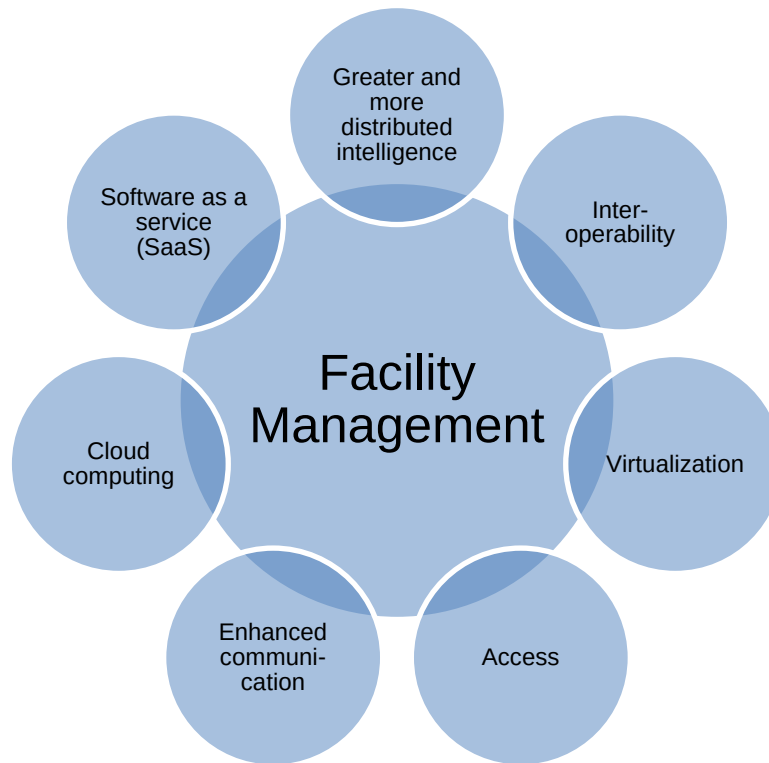
Greater and more distributed intelligence

The rapid increase in microprocessor speed and capacity makes possible:

- Smarter sensor networks in buildings, sensor nodes that can store data, send messages and receive instructions—sometimes wirelessly.
- Automated actions that can save time and money. One facility management consultant noted that simply automating the entry of occupant responses to a facility audit reduced the costs of that activity by 75 percent.
- Systems that can display multiple layers of information about a given object and relate separate objects.
- Business analytics software that can collect data from multiple systems in real time and analyze the data to support decision making.



Exhibit 6-6: Technology Trends and Facility Management



Interoperability

One of the greatest obstacles in implementing facility management systems is achieving interoperability among the different special-purpose systems that a facility has acquired over the years. Systems providers have tended to use proprietary technology that discouraged networking facility management tools, making management more difficult and preventing facility managers from getting full value from their technology investments. Facility managers must use controllers to combine and act on input from different systems. These controllers themselves, because they support specific system products, can limit a facility manager's choice of building systems.

There has been movement toward harmonization of standards and communication protocols, however. BACnet™ (for Building Automation and Control networks), is an open communication protocol that supports interoperability among different devices. It became an ASHRAE/ANSI standard in 1995 and an ISO standard in 2003.

A similar but proprietary product, LonWorks® (originally LonTalk), was released in 1999 and has been recognized by ISO/IEC. An increasing number of building control products build in these common protocols.

Another approach that has emerged is the use of online server applications that use the Internet Protocol (IP), the protocol used for the public Internet. The server acts as a gateway and translator to support data communication among building control components as well as voice communication, termed Voice over Internet Protocol or VoIP. Since IP is an open protocol, it is relatively inexpensive and is being included by manufacturers in their facility technology products.

IP offers several advantages:

- It supports wireless communication.
- It can allow integration of building control systems with the organization's business-level systems and its enterprise management applications.
- It can be more cost-effective than traditional circuit-switched communications since calls use less transmission time. Calls can be compressed further using data-compression tools.

There are disadvantages to IP, however, that facility managers must consider and manage if they choose to pursue this technology.

- **Number of server addresses.** Each connection over the Internet requires a static or dynamic IP address. A facility's server must be sized to support anticipated voice traffic. If it is undersized, transmissions can be slowed or dropped.
- **Transmission quality.** Although IP technology is the subject of intense development efforts, transmissions can be affected by connectivity "hiccups"—collisions of data packets sent back and forth that can cause delays and errors in transmission. These are perceived as the "talk over effect" and "jitter" (very brief delays) in VoIP and occasionally total loss of data in the course of a transmission. Transmission quality can also depend on the processing capability of the computer being used. If a computer does not have sufficient processing power, transmissions can be dropped when the user opens another application on the computer.
- **Guaranteed response times.** Because IP uses a packet-switched network broadcasting strategy, response times are not guaranteed. This can be problematic for high-performance applications.
- **Security.** Internet transmissions, including VoIP, are subject to intrusions, theft and tampering. Facility managers must work with their IT functions to ensure that their organizations' data is protected, that appropriate automatic protections are in place and that occupants are trained about safe computer use.



Did You Know?

The limited address issue associated with IP is improving. With each new generation of IP, the number of possible addresses increases. IPv4 had only about four billion addresses. IPv6 has about 3.4×10^{38} addresses, or 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses.

Virtualization

Virtualization in general refers to the conceptual creation of something actual. In a computing context, virtualization obscures the physical aspects of the relationship between a user and a computer system or network, but allows the user to perform the desired tasks—usually more quickly, reliably and inexpensively.

Virtualization can be used within individual computers and networks to improve performance and increase reliability. It can also be used to create host/guest server environments, and this form of virtualization may be of most interest to FM today. A virtual server can run multiple operating systems (OS) with multiple configurations for each. A virtual machine (VM) server can have up to 50 of these environments on one device or one “u” slot in a data center rack.

The effect is that one server appears to be many different servers with different functions. For example, one VM server can host:

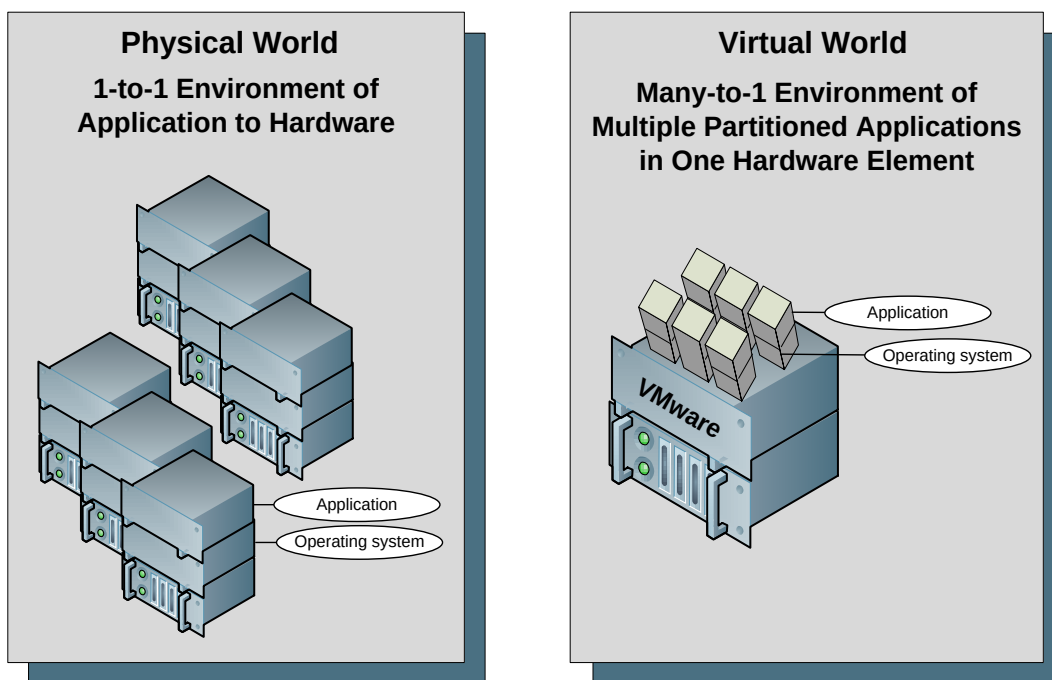
- Windows® 7 with Oracle® purchasing software.
- Apple OS running Apple’s version of Microsoft® Exchange.
- Sun Solaris (UNIX®) running the Remedyforce™ help desk application.
- Windows NT® Exchange Server.
- Any operating system running the organization’s intranet sites.

The concept of virtualization is illustrated in Exhibit 6-7 on the next page.

All of these applications are necessary to run an enterprise. With a VM server, FM needs to deliver power and air conditioning for only one machine rather than two racks or more of equipment in a data center. This relieves pressure on both operating costs and facility footprint.



Exhibit 6-7: A Physical Server Versus a Virtual Server



Cloud computing

In cloud computing, users can—via the Internet—store, access and process data that is stored at locations that can be anywhere. The users are hosted in vast IT facilities (which may use virtualization to implement cloud computing).

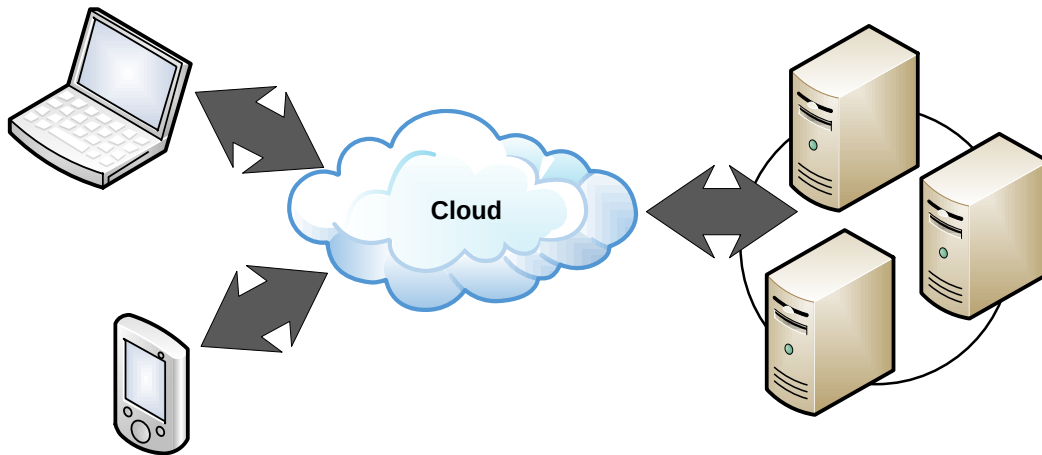
The major advantages of cloud computing are scalability and lower up-front costs. Organizations can buy just what they need, and they can avoid the expense of hardware purchase, costs for operating and housing the equipment and IT resources used to solve all-too-common installation and compatibility issues. Organizations can also share the financial risk of possible interruption of service.

Cloud computing services can be public (over the Internet), community-based (clients with similar needs for security or compliance) or private (dedicated to a single organization and operated by the organization itself or by a third party).

Exhibit 6-8 shows how users can enter the cloud from a variety of devices and access servers (sometimes arrayed in networks). The servers may be returning data or providing online access to a software application.



Exhibit 6-8: Cloud Computing



Software as a service

In software as a service (SaaS), the user does not own the application being used; the application resides at a remote location, rather than on the user's system, and the user accesses it through a cloud platform, usually for a fee. SaaS saves an organization the expense of managing multiple software licenses and maintaining the application through periodic updates and upgrades. It frees up IT time and processing and storage space on the organization's information system. Many facility management systems are now available as SaaS.

Access

The increase in access and control is due primarily to the growth of wireless communication and small, portable but powerful devices, such as smartphones or tablet computers.

In an intelligent building, remote sensors or motes can send data to wireless hubs which can then be sent on to controllers. Instructions based on this input can be returned, again wirelessly, to switches and actuators. This saves the expense of wiring, but also expands the use of wireless sensor networks in a building control environment. Another advantage of wireless systems is that they reduce a building's fire load or combustible components.

The most obvious use of wireless sensor networks is in managing a facility's climate and energy consumption, but there are other possibilities. For example, wireless security networks can make it easier to capture images from closed circuit TVs located throughout the facility, detect intrusions through an array of sensors, and control access at various facility

entry points. Wireless sensor networks could be integrated into a facility management tool to show in real time where parking spaces are available.

Access is also increased through mobile devices. Having a powerful computing device that is not tethered to an electrical outlet and a land line means that work can now occur wherever a secured wireless signal is available. Facility management staff can access systems at the work site or on the road. With each generation of wireless service, the amount of data that can be transmitted and the speed of transmission increases. New generations of mobile connectivity standards have appeared about every 10 years:

- 1G in 1981
- 2G in 1992
- 3G in 2001
- 4G in 2011

Facility managers should remember, however, that while mobility increases organizational productivity, it also increases occupant expectations. Occupants now expect excellent signals and performance wherever they are. Mobility has also extended the work hours, and occupants expect support 24/7.

Greater access also brings increased need for security to prevent unauthorized access or use of networks and data.

Enhanced communication

Technology has enabled the combination of voice, visuals and data into one communication event. Web meetings are now an effective way for organizations to avoid the economic and carbon costs and lost productive time associated with business travel. They are genuine tools for productivity. Meetings can be organized quickly. They add visual information to make aural messages more complete. They incorporate tools not available with face-to-face meetings, such as recordings.

While an online meeting is an example of enhanced synchronous (or occurring in real time) communication, technology and the Internet have also enhanced asynchronous communication. Blog posts, crowd sourcing and wikis are all ways that people can collaborate in a sequential but productive manner.



Impact on facility management

How do these trends affect facility managers?

- Management expects facility managers to be more than just familiar with the opportunities and requirements of current and emerging technologies. Facility managers must address in their own personal development plans the need for continuously adding technological knowledge. There are formal opportunities, such as IFMA's World Workplace, chapter and IT council meetings for professional associations and trade shows, but there are also ample informal opportunities:
 - Tour other facilities. Facility managers are usually eager to share what they have learned and accomplished in their own workplaces.
 - Benchmark the best. Identify facilities that are known for using technology well and in an innovative manner and ask for a tour.
 - Talk to younger team members who may be able to share experience from school or from the technology they use in their personal lives.
 - Network with IT personnel and learn the language and concepts.
- Facility managers must develop a close partnership with IT. This necessary relationship is discussed more fully later in this chapter.
- Facility and occupant surveys should include questions about facility technology, including its adequacy for occupant needs and reliability.
- Facility managers must also learn to use business analytics—identify what measures are appropriate for their organization's objectives, ensure that the right data is being collected, draw valid and constructive conclusions from that data and present results effectively to management.
- Facility managers must become effective leaders of change and managers of technology projects.
- Finally, facility managers should become more aware of the workplace and functions they support—the perspectives of other stakeholders in the organization. They must learn to see the facility from these groups' perspectives and creatively match their needs with appropriate facility technology. Stakeholder needs and facility technology are discussed in the next topic.



✦ Topic 3: Using Technology to Meet Stakeholder Needs

Stakeholders and technology

Given the focus on strategic management today, competency in the latest facility technology offers a facility manager valuable professional advantages. A facility manager who can identify the various needs of stakeholders both inside and outside the organization and use technology to address those needs in a cost-effective manner becomes a more valuable member of the organization's strategic management team. Technology helps expand what facility management offers beyond delivery of services to strategic contributions.

To make the most of technological competence, however, facility managers must find a way to become involved at an earlier stage in strategic planning. Opportunities for greater efficiency and building performance may be limited or eliminated entirely by decisions made during a project's design phase. As the discussion of building information modeling (BIM) in Chapter 3 will show, new technology can be deployed in a way that folds an entire structure and its entire lifespan into a single database—the history of every building component, its present status and its future replacement or modification.

One way to earn a place in these early discussions is to use awareness of stakeholder needs to build networks of influence and to use competence in innovative technological tools to build solutions that benefit individual stakeholders, the facility management function and the entire organization. The stakeholder theory of strategic management proposes that different participants in an organization have different goals, and these goals define their needs and expectations. Stakeholders are those who stand to gain in some way from their relationship with the organization. They can be internal or external to the organization.

Exhibits 6-9 and 6-10 on the following pages list examples of internal and external stakeholders and their needs, the solutions to which often rest in technology tools that facility managers can deploy. The lists are not exhaustive and may not be true for every organization. Organizations are different, and facility managers should make it a practice to communicate with internal and external stakeholders (where possible), ask about their priorities and listen carefully.



Exhibit 6-9: Internal Stakeholder Needs

Examples of Stakeholder and Needs	Discussion
Senior management • Economic performance • Risk management • Compliance • Transparency	Senior management (or the C-suite level) is ultimately responsible for the organization's ability to meet its strategic objectives, including its financial performance goals. Therefore, they welcome any increases in asset value, decreases in operating expenses and cost-effective actions that protect the organization from foreseeable loss. This includes failure to comply with laws and regulations. They need facility technology to show how the organization is performing—from a variety of measures—and they need that data to be accurate and timely, because they will be basing critical decisions on this information.
Boards of directors • Governance • Public image • Sustainability	Boards of directors are responsible for an organization's governance—ensuring that the organization's policies are followed and that management is directing the organization toward agreed goals. They are concerned about maintaining the organization's positive public image and fulfilling its responsibilities to its stakeholders. Increasingly, those responsibilities include sustainable organizational policies and processes.
Line management • Fulfillment of function objectives • Ability to attract talent • Lower costs (in cost allocation systems)	Line managers of individual functions are concerned with productivity, because this is how their performance will be judged by senior management. Their people need to be able to get their work done. And the function needs a reliable supply of future workers. The quality of the facility affects the functions' ability to attract talent. They also need technology that ensures productivity and gives them flexible and powerful reporting tools. NOTE: Facility management has a close relationship with certain functions, such as Finance and human resources. However, the relationship with IT is especially and mutually important. It merits a closer discussion, which follows Exhibit 6-10.
Occupants • Safety and security • Health, cleanliness and comfort • Pride in association • Amenities that provide convenience and quality service	Occupants want a safe, secure, healthy, clean and comfortable place in which to work. They want the tools they need to succeed, and they want to be proud of their workplace and organization. Part of that pride stems from the quality of services the facility provides, the care the organization has taken to respond to their work-related and non-work-related needs.
Facility management staff • Safety • Convenience • Job skill growth and opportunities for advancement or mobility	Facility management staff, like other occupants, wants a safe and healthful workplace, effective tools to perform their work, and supportive co-workers and managers. They expect technology to make their jobs easier, not harder. This means that they want to be trained before they are asked to perform. On the whole, staff members, especially younger employees, want to acquire the skills and knowledge that new technology offers.



Exhibit 6-10: External Stakeholder Needs

Stakeholder Needs	Discussion
Investors or shareholders - Financial performance - Security - Transparency	Investors or shareholders want the value of their investment to increase and to be as free of risk as possible. Their needs can be met through facility technology that increases efficiency and productivity, identifies and manages risks to the facility's operation and provides more information about factors affecting the organization's value and performance.
Tenants and their occupants - Lower operating costs - Safe, secure, healthful and productive workplace - Quality services and convenient amenities	Like line managers (especially those to whom facility costs are allocated), tenants are concerned about ways technology can decrease space and utility costs and increase occupant productivity. Their needs can be met by facility technology that decreases energy use, provides flexibility to meet specific work requirements and supports employee productivity.
Customers and visitors - Safe, secure and healthful facility - Uninterrupted service - Responsiveness	Facility visitors, including contractors, expect the same facility conditions as any other occupant. Customers also expect reliable and economic access to the product or service they are purchasing. Their needs can be met by facility technology that ensures the quality of the facility environment and reduces risk of interruption of facility services.
Suppliers Communication	Suppliers want to make their own processes easier and more reliable, and this usually depends on more effective sharing of information between the organization and the supplier. Facility technology that provides appropriately secure access to facility information will benefit both the organization and the supplier.
Occupants' families - Safe, secure, healthy workplaces for family members - Communication	Occupants' families want peace of mind and reliable communication among family members, especially in the event of facility emergencies.
Regulatory agencies Reporting of required information in an accurate and timely manner	Regulators simply want to do their jobs, too, which means getting required reports at the right times, with current and accurate data. Facility technology that automates this process benefits both sides.
Local neighbors and communities - Safe, secure and healthful environment - Communication	Communities want quality of life and open, transparent communication. Their needs are met by facility technology that helps decrease environmental risks and ensures timely communication during emergencies.



FM and IT

The relationship between IT and FM has evolved as their individual needs have become more complex. Today these two functions must collaborate to succeed. That requires that each partner understand the needs of the other and find ways to accommodate those needs. FM and IT managers must seek opportunities to establish and strengthen the relationship, to open channels of communication between the functions and to take advantage of each function's expertise.

IT's needs

Its critical role in most organizations has made the IT function particularly concerned about factors that affect its work:

- **The quality of support services it receives.** Most IT functions cannot tolerate even brief disruptions or conditions that may impair data and transmission quality. As a result, as an FM customer, IT has significant critical needs, including:
 - Space for equipment (e.g., server and network space, data centers) as well as climate conditioning for those spaces (e.g., cooling, humidity control, air filtration) and necessary electrical wiring and communication cabling (which may be installed in ceiling spaces or under raised floors). These spaces will need to be located carefully to manage risks to IT operations, decrease possible interference and ensure efficient and effective connections to land-based, satellite or wireless networks. IT may also need room to grow.
 - The right type of space for IT employees. These employees may need more collaborative space, more bench space for equipment, greater flexibility in terms of space use or housekeeping standards and in facility operating schedules.
 - Public and private network access
 - A reliable and quality power supply as well as emergency backup power supplies
 - Special purpose fire protection systems
 - In some instances, backup sites where IT can continue operations during facility disruptions
 - Security for sensitive equipment (e.g., locked rooms, video surveillance)
 - Automated alerts to detect possible issues quickly (e.g., temperature/humidity deviations, water leaks in data spaces)
 - Early notification for planned utility outages



- **Its workload.** In addition to its strategic assignments, the IT function usually manages computer hardware and software and often provides support to other functions, especially when functional software applications are integrated with the organization's ERP platform. IT management is sensitive therefore to any decisions in other functions that could become drains on its limited resources—for example, applications that are not fully compatible with the ERP, functional processes that can compete for computer time with IT or organizational processes, or practices that could pose security threats to the organization's information system. IT may become the “technical buyer” in the process of acquiring new systems. In other words, their review and approval is required before a function can complete a purchase. Functions must ensure that all new technology meets IT's published standards. In addition, IT would prefer to control the number of computer applications and software licenses that they have to track and maintain. Therefore they limit functions' choices for new software to a few alternatives.
- **Its governance responsibility.** IT is especially concerned with the issue of governance for a number of reasons. First, it represents a significant investment by the organization, and it must therefore be able to demonstrate to stakeholders that it is delivering the anticipated value to the organization. Second, because it is essentially a steward of the organization's data and automated processes, IT often has compliance responsibilities for issues such as data handling and data privacy and security. Third, because data and analysis both support management risk assessment and decisions, IT must ensure the integrity and transparency of its data and processes.

As a facility customer, IT can be demanding. The function uses a large amount of energy (directly or indirectly, through increased cooling needs) and can produce more challenging waste, in the form of discarded electronic components. They require fast responses to facility-related problems.

Data centers present specific and unique infrastructure needs and require FM to work with IT to develop approaches to operations and maintenance projects and tasks. The requirements of data centers are discussed in greater depth in Chapter 6, “Implementing Technology Projects.”

These needs may conflict with facility management's commitment to energy efficiency, which calls for an active partnership between the two to find ways to meet both IT and energy conservation needs by applying “green IT” policies.

As the technical buyer for new organizational and facility technology, IT also wants to control its workload and limit risks of program incompatibilities and



interference. If FM does not involve IT in technology acquisitions early in the process, facility managers can find themselves waiting for months for IT to assess and approve a software purchase.

FM's needs

FM is also a customer of IT. The increased use of building technology requires IT assistance in selecting, implementing and supporting products; creating and maintaining networks; and maintaining databases. IT must understand FM's responsibility:

- To operate the facility efficiently and effectively. Increasingly, this goal requires the use of new and complex technology.
- To support senior management decisions with current and quality data on building performance.
- To control building operation costs. Space needs must be accommodated, but FM is obligated to allocate space efficiently.
- To support the organization's sustainability. FM is committed to decreasing the facility's energy use and waste.

Building a strong IT/FM relationship

Unquestionably, IT and FM need each other. Creating a productive collaboration can begin with conversations in which IT and FM educate each about the other's strategic goals and requirements. Other ingredients for a better relationship could include:

- Discussing the organization's sustainability policy with IT and working together to implement "green" computing practices. "Green computing" focuses on sustainable goals such as:
 - Increasing energy efficiency of computing equipment. This can be achieved by purchasing equipment with more efficient power supply units and by ensuring that users employ power management modes (e.g., "sleep" or hibernation settings).
 - Decreasing the use of finite materials in computer products by emphasizing the use of recycled content.
 - Decreasing the amount of waste, especially toxic waste, from decommissioned computer equipment through redesign.
 - Decreasing use of energy and facility space through greater use of virtualization and cloud computing.
- Involving IT early in the process of acquiring new building technology.
- Defining service level agreements for each side—e.g., for IT, infrastructure and FM service requirements; for FM, required IT support levels, outage frequency and duration.



- Negotiating solutions to operational or scheduling conflicts or “rules of engagement,” such as finding mutually acceptable times for performing system maintenance tasks.
- Working together to identify and address possible issues, such as protecting IT equipment from the effects of nearby construction or remodeling work or preparing for emergencies.

The relationship can be more challenging if some or all of the FM or IT or both functions are outsourced—and then possibly subcontracted to a number of service providers. The managers of both functions must understand the risks of poor coordination and work to clarify expectations and improve communication channels.



Progress Check Questions

Directions: Read each question and respond in the space provided. Answers and page references follow the questions.

1. The organizational strategic plan is to an organization as the _____ is to facility management.
2. List at least three benefits that advanced building technologies can deliver to the facility management organization.

Match the organizational trends on the left with the correct implication for facility managers on the right.

- | | |
|--|------------------------------------|
| 3. _____ Growing importance of knowledge workers | a. Access to career building tools |
| 4. _____ Globalization | b. Energy conservation practices |
| 5. _____ Sustainability | c. Use of social media |
| 6. _____ Economic competition | d. Distance communication systems |
| 7. _____ Diverse workforces | e. Minimizing process disruption |

8. A facility manager plans to implement an automated hot desk reservation system to respond to the conversion of a large segment of the organization's workforce into remote workers or telecommuters. The group of employees is very diverse in terms of age. How will this affect the facility manager's response?

9. Which of the following would be a good example of virtualization?
() a. A building automation system
() b. Purchasing an automated system as SaaS
() c. Graphically depicting energy use in a building
() d. Deploying a remote sensor network to monitor room occupancy



10. Internet Protocol (IP) is best described as a
- () a. programming language.
 - () b. proprietary tool for integrating network devices.
 - () c. distributed and intelligent processing.
 - () d. an open standard used in online communications.
11. What has been one of the greatest challenges to the adoption of integrated, automated facility technology?
- () a. Proprietary technology
 - () b. Intellectual property law
 - () c. An increasingly multicultural user base
 - () d. User resistance

Match the stakeholder on the left with the correct primary interest on the right.

- | | |
|-----------------------------|--|
| 12. _____ Senior management | a. Healthy, comfortable, clean workplace |
| 13. _____ Line management | b. Training to use new tools |
| 14. _____ Occupants | c. Access to facility information |
| 15. _____ Suppliers | d. Lower energy bills |
| 16. _____ FM technicians | e. Employee productivity |
| 17. _____ IT | f. FM support, workload and governance |



Progress check answers

1. The organizational strategic plan is to an organization as the strategic facility plan is to facility management. (p. 6-6)
2. Benefits of advanced building technology for organizations could include cost savings, alignment with organizational values, improved governance, increased facility customer satisfaction, documented compliance, and organizational knowledge management. (p. 6-7)
3. a (p. 6-13)
4. d (p. 6-12)
5. b (p. 6-13)
6. e (p. 6-12)
7. c (p. 6-14)
8. The employees will probably have different attitudes toward and familiarity with automated technology. The facility manager should plan to involve employees in the development of the system and incorporate training and support for those less interested in and adept with technology. (p. 6-14)
9. b. Virtualization is creating the appearance of reality. SaaS creates the appearance that an organization owns and possesses on-site a software application, while in reality the application is hosted off-site by a third party. (p. 6-17)
10. d. Internet Protocol (IP) is an open protocol, or communication language, by which different systems can interact in an online methodology. (p. 6-16)
11. a. Proprietary technology has created systems that cannot be easily integrated, resulting in facilities having to operate multiple systems independently. (p. 6-15)
12. d (p. 6-23)
13. e (p. 6-23)
14. a (p. 6-23)
15. c (p. 6-24)
16. b (p. 6-23)
17. f (p. 6-25)



Chapter 2: Control and Integration Systems

After completing this chapter, students will be able to:

- List benefits of automated technology for facility management
 - Provides examples of how automation can be implemented poorly in a facility.
 - Describe how a building automation system (BAS) functions.
 - List the benefits of a BAS to an organization and its requirements of facility management.
 - Describe the functions and analytics performed by an energy management system and energy analytic software.
 - List the types of capabilities performed by an integrated workplace management system, including such components as:
 - Computerized automated facility management (CAFM)
 - Computerized maintenance management systems (CMMS)
 - Environment, health and safety systems.
 - Summarize factors to consider when purchasing automated, integrated facility technology.
-

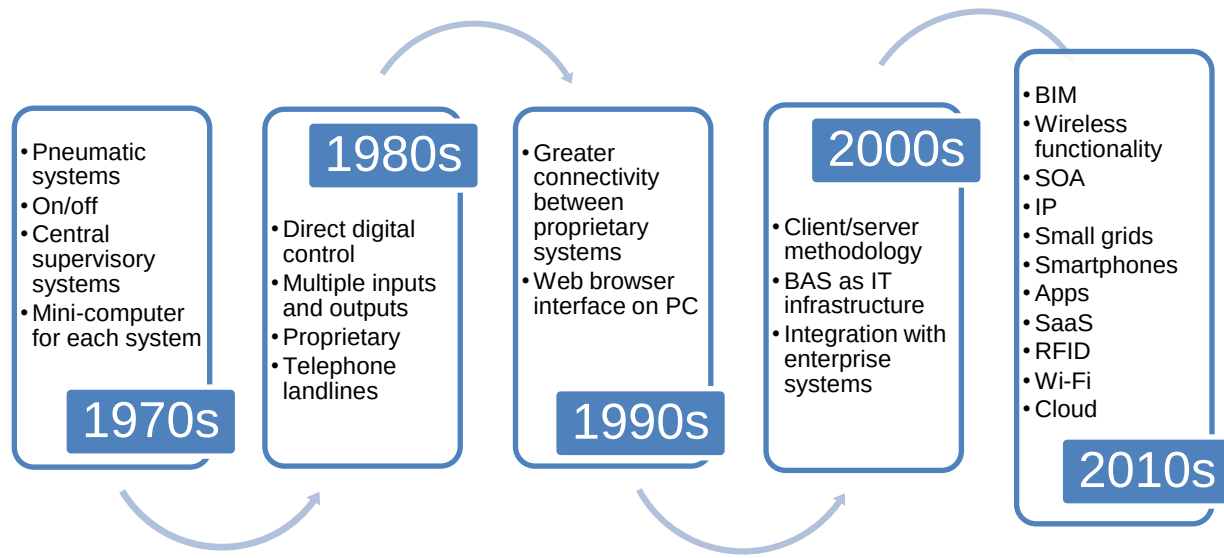
✦ Topic 1: Building Technology

Building technology has evolved in functionality as manufacturers have taken advantage of advances in computing and communication technology—for example, adopting the graphic user interface as a replacement for command line interfaces which required a great deal of learning and memory. Although the early controls may be dwarfed by the functionality of today's systems, even the first, limited products opened facility managers' eyes to what new technology could conceivably accomplish.

As Exhibit 6-11 on the next page shows, the evolution of building technology could be summarized in the following stages:

- 1970s: The earliest systems were pneumatic controls. They were automated to the extent that a control system (e.g., a commercial thermostat) was hardwired to a relay to start or stop systems based on pressure readings. There was no information coming back to the control system from the building system.



Exhibit 6-11: Building Technology Evolution

As digital devices became more commercially available, building automation systems (BAS) were introduced. Today's BAS (or building management system [BMS]) is an integrated, automated system that controls several aspects of building operations, such as HVAC, lighting, elevators, fire suppression and security. Early BAS, however, used mini-computers to create a central supervisory system. Each system controlled a specific function which could be controlled from a dedicated terminal. Communication with system devices used a proprietary language.

- **1980s:** Direct digital control provided a closed loop—a cycle of input, processing and output—which enabled two-way communication and more accurate control of system devices. Additional loops could be added to the BAS HVAC loop to control non-HVAC systems, such as lighting. Displays became more graphical. Satellite properties could be connected to the main control point by using telephone land lines.
- **1990s:** Greater memory and processing capability at each device increased the amount of information available to facility managers. Facility managers could also choose systems from different vendors. Manufacturers created gateways (“middleware”) that would allow a controller from one manufacturer to communicate with devices from another manufacturer. Gradually proprietary communication protocols began to give way to standard open protocols (i.e., LonTalk, BACnet, Internet Protocol, XML). The BAS interface also evolved, using the look of a Web browser, such as Microsoft Internet Explorer®.



- 2000s: BAS adopted a client-server architecture, with devices exchanging data via IP with enterprise servers usually managed by the organization's IT function. Organizations could integrate facility operation data with enterprise data. Wireless technology could be used to network facility devices and controllers, as well as to access the BAS. Increases in processing powers again elevated the level of information and automated control available to facility managers. Controlling became continuous—rather than being performed at intervals—and adaptive, with decisions often based on complex algorithms.
- 2010s: This decade is harvesting the results of advances in processing, connectivity and mobility as well as the convergence of these trends. Many of the items listed in Exhibit 6-11, such as cloud computing and SaaS, were introduced in the previous chapter, and advanced building technology such as building information modeling (BIM) and radio frequency identification (RFID) will be discussed in the next chapter. Other developments include new network configurations, such as small grids, a form of distributed or parallel computing in which autonomous computers are connected, often through the public network, to complete certain tasks. Service-oriented architecture (SOA) is a set of principles and methodologies for designing and developing software in the form of interoperable services. These services are well-defined business functionalities that are built as software components (discrete pieces of code and/or data structures) that can be reused for different purposes. SOA design principles are used during the phases of systems development and integration. Web-based applications use a similar approach, referred to as Simple Object Access Protocol (SOAP). This has enabled organizations or service providers to redefine some tasks as online, self-service processes. Wireless networks (referred to often by the term *Wi-Fi*TM) can offer high-speed connections over the Internet in many locations. Customers can use smartphones or tablets to connect wirelessly and view and retrieve data and run applications that were previously possible only on personal computers.

Systems from all of these eras are probably still in use somewhere, and as mentioned earlier, managing these legacy systems is a challenge. And building technology will continue to evolve. Instead of graphic user interfaces, future technologies could employ spoken language as an interface. Embedded intelligence and memory will continue to increase, allowing devices to consider complex conditions before acting. Some applications may be delivered via the cloud.



Automated technology

Central to the technology described in this chapter is the concept of automation. The facility technology tools discussed in this chapter have three primary features. They:

- Capture and store more information than was previously possible.
- Process or analyze this information to automate certain decisions.
- Integrate different processes—from mechanical processes such as ventilation to organizational processes such as moves—for greater efficiency.

Technology has allowed the facility manager to transfer a large number of decisions to intelligent systems and focus on making and improving the quality of larger, strategic decisions. The best way to illustrate this shift is to imagine a time in which a building was heated by a maintenance staff (or person) who would manually operate boilers, opening and closing lines with wrenches, watching gauges to make decisions and detect problems with the equipment. Now an automated HVAC system is programmed to coordinate the use of ventilation and heating (and cooling) systems to reach and maintain preset indoor temperatures (probably in zones) during defined time periods. Once the system is successfully defined, a facility manager may not intervene in its operation again unless the system issues an alarm or until changes in the organization's needs require changes to the system.

Benefits of automation for facility managers

Intelligent, automated facility systems benefit the facility management function and its organization in a number of ways:

- They increase the productivity of facility management staff. Fewer staff can manage a more complex facility. (However, there is an important caveat to this that is discussed below.)
- Since automated processes occur more frequently and with greater precision than manual processes, organizations can—potentially—decrease operating costs.
- Accountability and transparency, which are important issues in organizations today, increase in automated, intelligent systems. More verifiable data is available more quickly and more easily.
- These systems are capable of integrating processes and data from various sources. They have the potential therefore to create additional efficiencies and remove obstacles and conflicts.
- Intelligent systems—properly specified, installed and operated—make FM organizations more intelligent. They can collect and preserve information about systems/component and FM experiences so that the function as a whole can learn from the past, can share data in real time and remotely with team members and vendors, and ensure that past knowledge will be available to future managers and technicians. This shared information can be used to recognize trends and analyze options and make better decisions.



Some warnings about automated technology

Facility management technology clearly has enormous potential benefits, but optimizing those benefits takes true systems thinking, understanding how all the components of a process affect each other. Facility managers must remember:

- Automated processes depend on a large amount of accurate data. Effective processes cannot be built on insufficient, incorrect or obsolete data. Collecting and inputting the data into a new system will require significant facility resources, and demands planning.
- Processes that are flawed to begin with will only be performed more quickly and easily with automated tools—same poor outcomes, but with the higher cost of the technology investment. Technology adds efficiency; it does not, by itself, create effectiveness. All processes should be reviewed to verify outcomes and ensure effectiveness and alignment with the organization's resources and policies. Some may have to be reengineered.
- The needs of the technology and the organization must be considered. Complex processes require fast and accurate communication. Communication systems must provide new technology with sufficient bandwidth to ensure adequate speeds. As mentioned in the previous chapter, the early involvement of IT in assessing technology options is essential. Technology tools that support integration of facility and enterprise data require IT's breadth of knowledge about applications the rest of the organization is using and their specific requirements, as well as the ability to support the integration.
- The issue of legacy systems must be faced. As buildings age and/or grow, they tend to acquire multiple, and possibly proprietary, systems to control different building functions, such as lighting, access control, lifts, closed circuit television (CCTV). It may be difficult to integrate these multiple systems. This is an issue that must be addressed during acquisition discussions, both to manage better the present need for integration and to prevent future limitations that the proposed technology may impose—in other words, to avoid getting boxed into a solution that may prove costly and restrictive over time.
- Facility managers should think about resources beyond those required for acquisition. Ensuring the performance of the system once it is operating will also take resources, as well as ongoing commitment. To ensure system performance, system outputs must be verified after implementation and repeated at defined intervals to ensure that processes are being performed as planned with the anticipated results. The entire system must be documented, including data standards, rationales for decisions, testing results, and changes to the system over time.



Did You Know?

Checking the performance of building systems after installation is referred to as commissioning, a term that derived from ship building. Ships would be “commissioned” before setting sail to ensure their readiness for service. Commissioning considers not only installation issues but also training for those tasked with maintaining the desired performance. A ten-year study by the Lawrence Berkeley National Laboratories of building commissioning projects supported the economic value of commissioning new technology. Improperly implemented, even sophisticated technology will not be able to achieve the anticipated performance.

- One must also appreciate the fact that automated processes still involve human beings, and the interaction of staff and automated systems must be carefully considered and monitored.
 - Adopting technological tools will change the jobs of almost everyone in facility management. New knowledge and skills will be needed. Job descriptions and hiring profiles will need to be rewritten. Training will need to be developed and delivered.
 - Staff must be prepared for false alarms. Systems will invariably generate erroneous alarms, but if this happens frequently, false alarms can mask genuine alarms. Conditions that generate false alarms should be addressed, and staff should be cautioned about the dangers of assuming that every alarm is a false alarm.

The previous points underscore another warning. Because implementing facility technology involves a significant investment of resources and because technology may affect processes throughout the organization, technology projects will require a commitment from the organization’s management. Their commitment will not guarantee the project’s success, but not having it will guarantee the project’s failure.

Topic 2: Building Automation Systems (BAS)

BAS history

A building automation system is an integrated, automated system that controls several aspects of building operations, such as HVAC, lighting, energy, elevators, fire suppression and security.

BAS are known by a variety of names and acronyms, including building management systems (BMS) and building automation and control systems (BACS). The variety of names may be related to the fact that these facility



management tools did not appear on the market fully formed, but have evolved slowly, taking advantage of computing advances to promote levels of automation and control.

Capabilities and benefits

Systems will vary in functionality, but in general a BAS can:

- Provide real-time status information from every system component, including temperature and carbon dioxide sensor readings, variable frequency drive (VFD) fan speeds and damper positions.
- Monitor energy consumption and apply controls to reduce waste or avoid increased charges based on demand rate. These functions are performed by the energy management module of the BAS, which is discussed more fully in the next topic.
- Issue alarms. An alarm indicates that a specific system component is not performing within defined parameters; alarms can be sent by e-mail, phone or other means to designated contacts. The system will also store alarm histories. This function facilitates the identification and speedy resolution of performance issues.
- Sequence equipment for greater efficiency or to reduce the risk of over-tasking a system through simultaneous demands.
- Schedule operations, such as HVAC and lighting according to hours of occupancy.
- Implement complex processes such as demand-controlled ventilation, in which the delivery of fresh air into a workspace is controlled dynamically according carbon dioxide levels. This ensures a healthful indoor air quality, but also reduces energy spent conditioning fresh air that is not required.
- Manage wear and tear on system components through duty cycling.
- Trend and analyze data to support commissioning a system, planning maintenance and replacement schedules, and building a case study for system improvements. In integrated systems, reports can include data pulled from other, non-BAS systems, such as human resources. These reports are an example of “business intelligence,” the ability of an organization to capture and distribute the right information at the right level to the right people to support their specific responsibilities. These reports can be customized to the needs of different stakeholders. For example, senior management may receive dashboard-style reports that provide a high-level assessment of the facility’s performance. FM can receive more detailed reports—for example, performance history for a particular component, including alarms generated by the system.

Exhibit 6-12 translates these capabilities into benefits to facility managers and their organizations.



Exhibit 6-12: BAS Benefits to FM

Capability: Real-time system status information

- Faster detection of problems, which means faster technician response time, which means greater occupant satisfaction
- Better and more timely information for dashboard reports of facility performance, which leads to increased stakeholder satisfaction
- Increased security at facility or data center, which lowers organizational vulnerability and chances for business disruptions and loss

Capability: Energy consumption monitoring

- Better understanding of facility energy consumption patterns
- Identification of wasteful areas and practices and more targeted energy conservation measures
- Lowering peak usage and avoiding additional demand-related energy charges

Capability: Performance alarms

- Reduced risk of possible future interruptions of service and management/occupant dissatisfaction
- Potential energy savings
- Longer equipment life
- Reduced maintenance costs

Capability: Sequencing

- Reduced energy consumption and lowered costs of operation

Capability: Scheduling

- Optimized start and stop times for equipment to reduce energy waste
- Inclusion of multiple factors, such as seasonal daytime temperature trends and occupancy levels
- Reduced energy cost due to on-peak and off-peak scheduling
- Greater occupant comfort

Capability: Demand-controlled ventilation (DCV)

- Increased fresh air intake to reduce levels of CO₂ and to dilute airborne contaminants, which improves indoor air quality and lowers rates of illness and increases productivity
- Decreased space conditioning costs since only enough unconditioned air is taken into the building as is actually needed to produce acceptable CO₂ levels

Capability: Duty cycling

- Less disruption from unanticipated failures
- Extended equipment life
- Better cash flow through managed replacement/repair

Capability: Performance data analysis

- Improved system performance by identifying and correcting commissioning issues
- Early warning of component degradation from analysis of alarms; less disruption of service/business
- Proof of energy performance to apply to energy performance contracts with vendors
- Greater transparency regarding investments
- Building consumption data for energy and water which can support compliance or real estate goals
- Economic analysis to support better decisions about energy conservation and technology investments
- Increased credibility with management
- Improved operational practices, leading to decreased operational costs, including labor
- Equipment performance data to support claims on warranties



BAS architecture

Because of their potential to help facilities use energy more efficiently and because of the documentation and analysis of performance they can provide, facilities who have implemented BAS receive credits in sustainable facility certification systems, such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM) and DGNB (German Association for Sustainable Construction).

A BAS is essentially an automated feedback loop, in which controllers communicate with devices and sensors, which in turn communicate back to the controllers.

As mentioned earlier, a building may have more than one BAS, each controlling different building systems. Since FM and building owners are reluctant to change or replace systems that are operating, buildings tend to acquire additional systems over time, as space or building features are added.

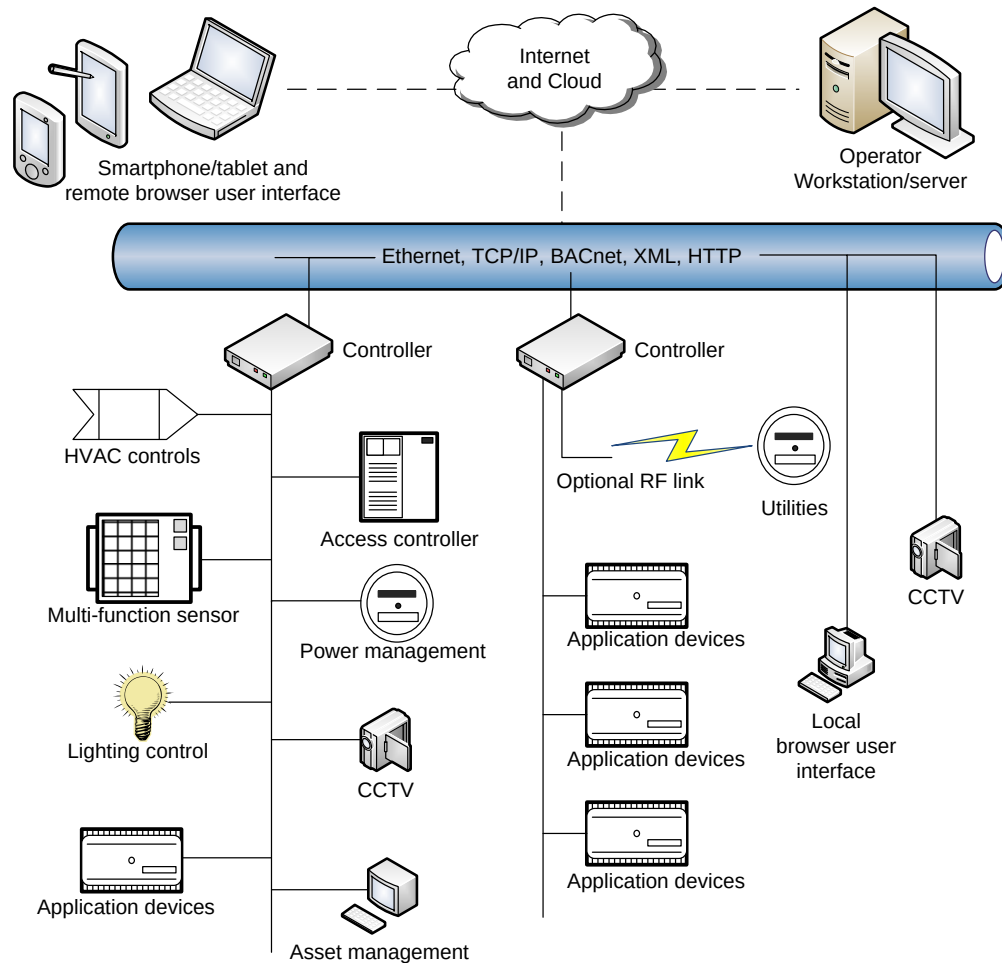
Airports are an interesting example of this challenge. Buildings are added to airport facilities continually to address the growth in air travel. Ticketing systems add communications requirements. Compliance requirements add security infrastructure. More travelers need to be moved quickly throughout the facility, which means more walkways and lifts. And these travelers expect amenities, such as wireless access and more plug-ins for mobile devices. Each addition may mean a new system, and FM and IT must find ways to create some degree of data integration.

Exhibit 6-13 on the next page illustrates a possible BAS architecture. Individual systems could be—and probably are—different.

The BAS illustrated includes, starting from the top of the illustration:

- A user interface—which can be a conventional workstation in the facility or a remote device, such as a laptop computer, a tablet or a smartphone—that allows facility managers and technicians to access and share system information so that the facility manager can:
 - Act (e.g., set climate parameters, determine sequences and schedules).
 - Monitor, diagnose performance issues and respond quickly.
 - Analyze data to support future actions that are wise for the facility and for the entire enterprise.
- Server(s) on which applications are run and data is stored. Alternatively, the user may access applications as SaaS over the cloud.



Exhibit 6-13: Sample BAS Design

- A supervisory network that manages communication (via a communication protocol, such as IP) between the user, the server(s) and the controllers for devices (e.g., HVAC). A software firewall protects the system from attacks that may come in via the Web and mobile devices.
- Controllers that manage communication between the network and the applications, devices or sensors.
- The applications, devices or sensors, which can store performance history that can be retrieved for analysis. This layer reflects the building's unique needs. For example, in addition to the applications shown in the illustration (e.g., HVAC and lighting controls, access controls, CCTV), it could include rain sensors and irrigation control, messaging systems, extensive fire detection and suppression systems or biometric security systems.



Purchasing a BAS

A facility's BAS may include multiple specific applications—from a single vendor or multiple vendors. In other words, a BAS purchased from company X may be combined (and underscore the words “may be”) with application software from other manufacturers to control security systems, interior and exterior lighting systems, irrigation systems, and so on.

An assumption of a new BAS is that it will use a tiered architecture that allows more flexibility in delivery and in meeting changing demand (i.e., scalability), greater security and compliance with future standards. Beyond that, the choice of product should be driven by the functionality the facility manager needs and the limits of existing facility equipment. Considerations should include:

- What energy-saving capabilities can be used and implemented, including:
 - Scheduling equipment operation by times and outdoor air temperatures and humidity levels.
 - Lockouts to prevent simultaneous operation of heating and cooling systems or inappropriate operation (e.g., operating the cooling system past a cutoff date).
 - Advanced control algorithms.
 - Electrical demand limiting. (This concept is discussed further in the next topic in this chapter.)
 - Advanced diagnostics.
 - Dependent energy-saving systems, such as presence detectors that adjust light and climate when occupants are present (e.g., in warehouse aisles or conference rooms) and provide access to certain levels of service in meeting rooms and window shading that is dependent on weather conditions and the position of the sun.
- Advanced user interfaces, such as remote HVAC control, user-customized views that can be accessed through passwords, and integration of data from other systems or platforms into the user's screen view.
- The organization's preferred payback period. The amount of performance that can be implemented may depend on whether the BAS must be designed to control legacy systems. In these cases, opportunities may be limited and payback periods will be longer. This is an important consideration since many organizations require payback periods no longer than 24 months for technology projects.



- The compatibility of the BAS protocol with facility devices. Most systems use open protocols now, and device manufacturers will design for different protocols. The ability to integrate existing equipment into a proposed BAS must be confirmed.

Did You Know?

The complexities of compatibility can be challenging for facility managers. One facility manager reported frustratingly different performance levels from two BAS controllers from the same vendor. One controller with a proprietary language functions well with the back end software and database. The other, with a BACnet protocol, poses problems in graphics, programming and operation. Facility managers need to network with their peers to learn about such issues and gain commitment from vendors to work through problems to a satisfactory resolution—perhaps through a commissioning requirement.

- Whether a Web browser is needed. A BAS with a Web browser can allow a facility manager to access and manage multiple facilities from a remote site. Staff can also access the system using a smartphone. A third party (e.g., a security company) could access and operate a subsystem.
- The degree to which the system supports the continuity of facility operations. Facility managers should ensure that systems plan for failure. Are there redundant or backup systems? Is a fail-safe mechanism included to mitigate the negative impacts of system or component failure? Are critical systems separated so that the failure of one system does not affect the other systems? What is the average recovery time after a system failure?
- Graphic display capabilities. Graphic data presentations can be customized to meet the needs of different users and audiences. For example, graphic depictions of the system can be created to support troubleshooting. Facility technicians can use “dashboards” to monitor system performance and quickly identify issues. Stakeholders interested in energy savings can compare a building’s carbon footprint with comparable structures or history.

Various industry research companies publish full descriptions and ratings summaries for BAS products from specific manufacturers. However, facility managers are well advised to remember two points. Ratings may not be driven by the same priorities and needs held by a facility manager’s own organization. A product with an excellent rating—with a range of mature capabilities—may not be the best answer for every facility. The second point to remember is that



while a sales representative can provide necessary, product-specific information, the best source of objective information about a BAS product is a fellow facility manager. Facility management is a collaborative, supportive discipline. One of the benefits of networking within the profession is access to colleagues' experiences with their own BAS.

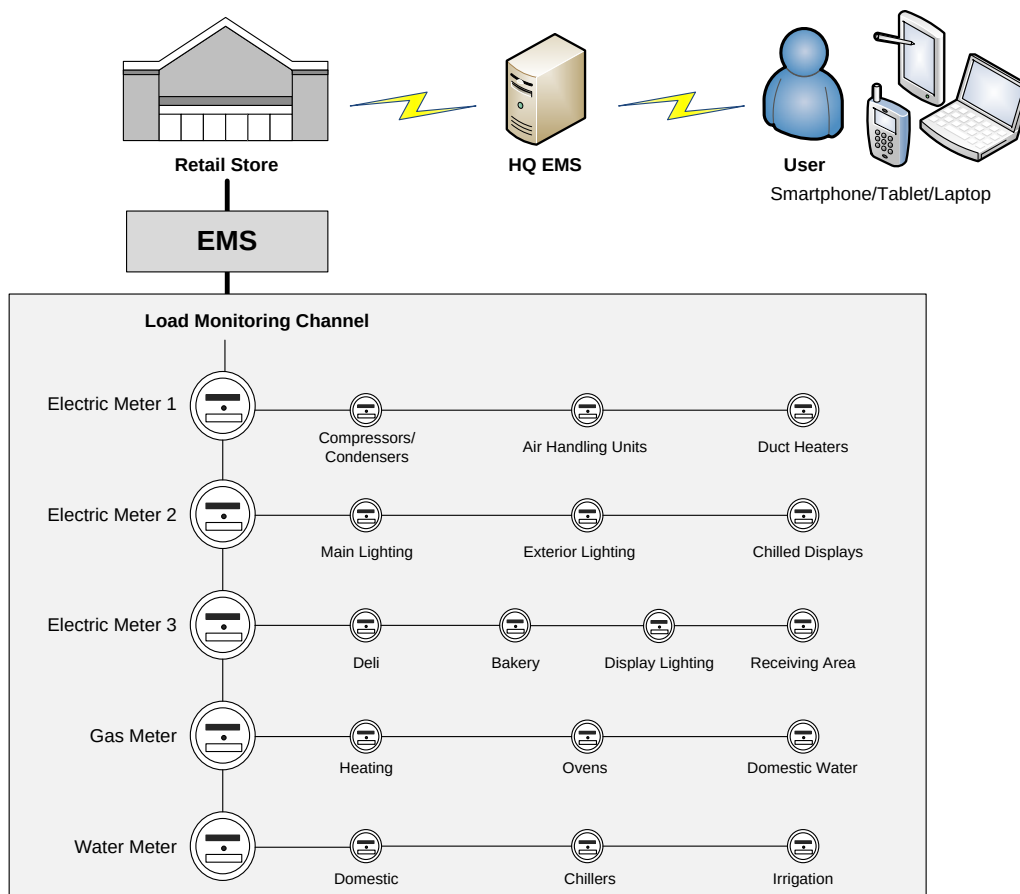
✦ Topic 3: Energy Management Systems (EMS)

EMS overview

Energy management systems (EMS), or energy management and control systems (EMCS), is a specialized function of BAS. The term *energy* should be understood in a broad sense. Although EMS started with a focus on electrical power, EMS are now designed to track the use of multiple forms of energy (e.g., electric, natural gas, fuel oil) as well as water. The systems monitor use, analyze and provide alarms/reports, and, in some cases, manage demand.

Exhibit 6-14 illustrates the use of an EMS in a retail store that is part of a chain managed from a separate headquarters.

Exhibit 6-14: EMS Use in a Retail Setting



The EMS installed at the retail store level includes a load monitoring function tied to various meters. This example shows three electric meters for different types of loads, a gas meter and a water meter. Each of these meters has been submetered to provide more detailed information about resource use. For example, the main interior lighting is metered separately from exterior (e.g., parking) lighting. Water used for irrigation is metered separately from water used for domestic or chilling purposes.

Information about use levels is conveyed to the EMS at the retail store's headquarters. This could be transmitted over the Internet, perhaps encrypted in a virtual private network (VPN). Consumption can be viewed in real time and data compiled. The system may set expected consumption levels, based on daily trends, and generate alarms only when those levels are exceeded. As indicated in the following section on demand management, the EMS may automate actions to reduce or shift consumption.

The concept of monitoring and responding to feedback in an automated manner is similar to the operation of a BAS. However, two capabilities of advanced EMS merit attention here: energy analytics and demand/load management. These topics are summarized here, but are discussed further in the *Environmental Stewardship and Sustainability* competency.

Energy analytics

Energy analysis software allows facility managers to track and analyze energy use by the whole facility, specific areas or specific systems or equipment. By installing submeters and smart meters (capable of storing and transmitting data about how much and at what time of day energy is being used), facility managers can get a better picture of how energy is consumed throughout the facility—the largest consumers, the times of day and the days of the week or seasons of the year at which consumption peaks.

This information can then be used in a variety of ways:

- **Forecasting use.** This analysis can be used to support various energy strategies, from capital investments in higher efficiency systems or on-site generation of sustainable energy to demand-management tactics (discussed below). For example, a trend analysis showing ever-increasing energy use in the facility's data center could become a starting point for a discussion with IT about sustainable data center alternatives.
- **Identification of opportunities for energy improvement investments.** For example, a facility breakdown of energy use by system might identify opportunities to improve energy efficiency in food service areas.



- **Testing of strategic energy tactics.** Software can support the creation and comparison of scenarios to test the cost-effectiveness of capital investments under different conditions, such as energy rate changes or level of efficiency achieved.
- **Advanced diagnostics.** Performance baselines can be created for most system components, and actual performance can be monitored and trended against that baseline. Problems that are causing inefficient use of energy or may indicate component failure can be identified quickly. Automated diagnostics can capture many times more data points than manual methods, which increases the odds of finding brief and rare events that could cause serious disruption.
- **Verifying service agreements with energy service contractors.** Energy performance contractors (EPCs) or energy service companies (ESCOs) work with facilities to deliver a certain level of energy performance for a fee or percentage of savings. This is essentially a risk-sharing arrangement: the client receives expertise and sometimes energy-saving equipment, and the contractor is rewarded if the client sees the promised increase in efficiency. EMS data can verify the results of the agreement. Energy performance contracting is also discussed in the *Environmental Stewardship and Sustainability* competency.
- **Commissioning new equipment and systems.** There is the efficiency promised by the sales representative—and the efficiency actually received. Investigating the performance gap identified during a commissioning analysis could lead to the discovery of technical and nontechnical causes. Sometimes the discrepancy may be due to incorrect or incomplete implementation or to poor integration. A facility manager may also discover that new equipment or systems are not being used correctly by staff because of insufficient skills, inadequate training or ineffective supervision.
- **Compliance.** An increasing number of municipalities and countries are requiring that buildings display their energy efficiency. An EMS can provide data needed to comply with energy reporting requirements. In response to the European Directive on the Energy Performance of Buildings (2002), European countries are implementing laws that require energy performance certificates or “passports” when buildings are constructed, sold or rented. This ensures full disclosure of energy performance data to prospective purchasers and tenants. In New York City, Local Law 84 requires owners of buildings of a certain size to report their buildings’ energy use.



Demand management

Electrical costs for a facility relate to amount of consumption and demand—the rate at which electricity is used. When electrical demand surpasses a preset kilowatt or hour level, the facility incurs an additional charge per kWh or for the peak demand (kW). The level and the charge may vary according to time of day, with peak, partial peak and off-peak periods. One industry expert has predicted that by 2020 peak cost per kWh will be a multiple of the base load rate. To manage energy costs, therefore, a facility needs to be able to manage the timing and level of demand.

EMS controls attack this challenge by aligning facility electricity use with the energy provider's rate structures through load limiting or shifting and demand-response agreements with energy providers.

Demand limiting or load shedding/shifting

Based on system analysis of energy consumption patterns, the facility manager can identify typical loads throughout the day, as well as short-lived spikes of use that can trigger additional charges. The EMS is programmed with “not to exceed” limits for each rate period, and, based on consumption patterns and the organization's agreed list of priorities, certain areas and/or processes will be suspended or rescheduled. The areas with the most critical need for temperature control may be adjusted last or not at all, if possible. For example, an industry may decide to make its dry ice at night if necessary, but will raise temperatures on the factory floor only as a last resort.

When the base meter indicates that the limit has been reached, the EMS begins to issue commands automatically to equipment in each area in the preset sequence. These commands are aimed at decreasing energy consumption. For example, thermostat settings may be automatically shifted upward during cooling seasons—by one degree at first and then by two degrees in a second round, if necessary. Chillers may be shut down or cycles shortened (as equipment allows).

Some EMS may be programmed to shift certain tasks from peak hours to off-peak hours automatically under certain conditions or at certain times of the year.

Some systems can use real-time energy pricing information to respond dynamically to changes in rates throughout the day, cutting and shifting loads in response to rate changes.



In some areas demand shifting is supported by utility companies who will pay facilities for the generation capacity that has been released back to the utility as a result of the facility's sound energy management. In this manner, the activity not only saves the organization money, but actually creates a facility-generated revenue opportunity.

Demand response

In some energy markets, EMS can automate facility participation in demand-response agreements. Under these agreements, the facility is rewarded for agreeing to lower its energy use upon request by the energy provider. For example, the facility might receive a preferential rate or might be paid to shed a committed amount of load. The EMS can automate the process so that it is transparent to the facility manager, although the facility can also opt for a non-automated process.

Implementing EMS

As stated previously, some BAS include various EMS capabilities, and facility managers should consider those features in choosing a BAS. To achieve the benefits of EMS, the organization must commit to investing in additional metering. The willingness to invest in EMS capabilities may depend on the price of energy, the significance of energy costs as a budget item, and the extent to which facility managers can make use of the analytic, display and control tools.

If a facility is using an energy contracting arrangement, an EMS may be part of the changes implemented under the contract. If a facility is not contracting with an ESCO, facility managers can refer to the *Environmental Stewardship and Sustainability* competency for more ideas on improving energy efficiency.

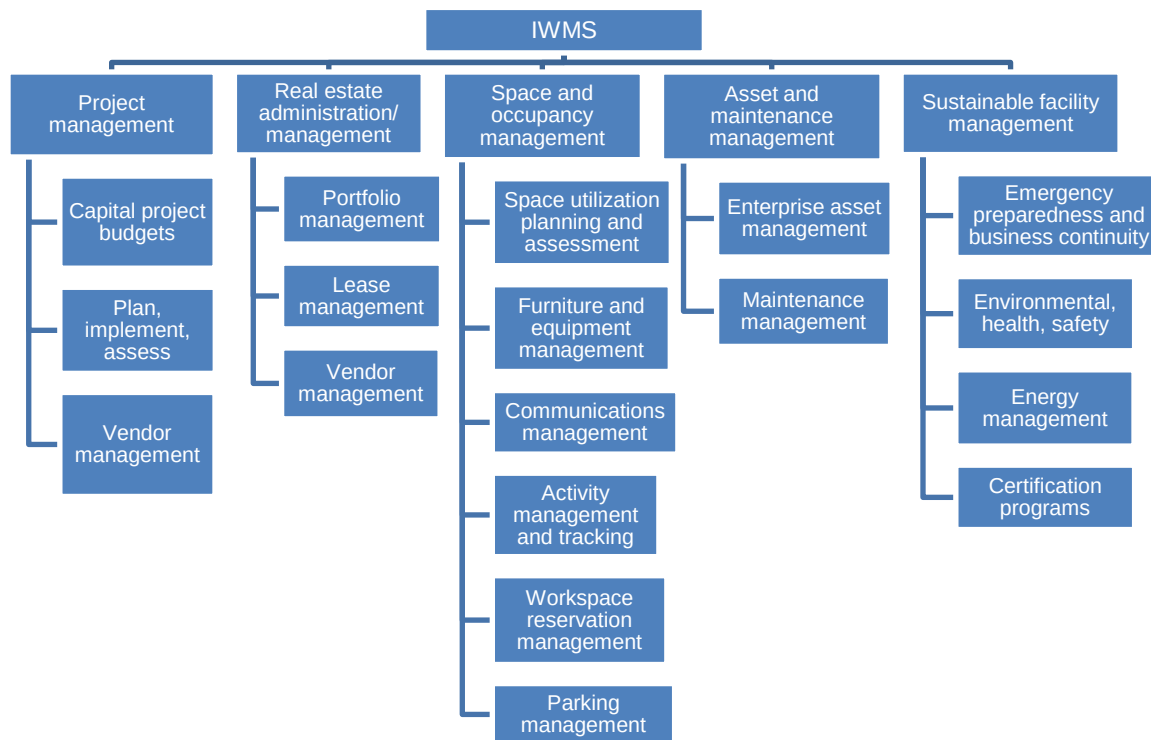
Topic 4: Integrated Workplace Management Systems

Definition of IWMS

An integrated workplace management system (IWMS) is an enterprise-level software platform that facilitates integration of data to create certain functionalities—usually in the areas of project management, real estate administration and portfolio management, space and occupancy management, asset and maintenance management, and sustainability.

As shown in Exhibit 6-15, each function can include multiple tasks that must be managed. Customers can choose systems with the functionality and flexibility that they require.



Exhibit 6-15: IWMS Solutions

These functionalities are described further below, but understanding the benefits of IWMS first requires understanding how facility management software has evolved and how IWMS “works.”

IWMS evolution

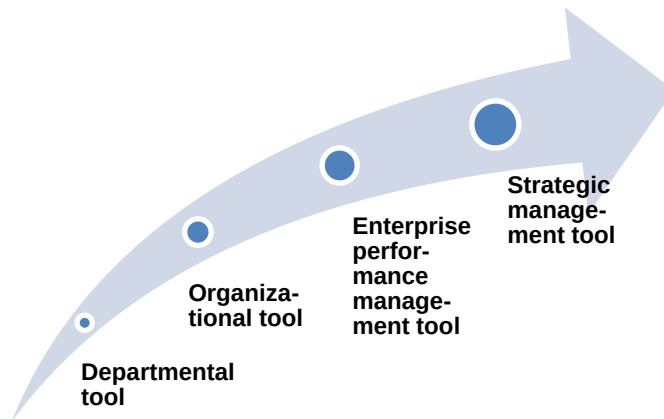
Technologies such as IWMS, computer-assisted facility management (CAFM) and computerized maintenance management systems (CMMS) focus on facility responsibilities other than operating and maintaining core building systems. The different acronyms reflect the evolution of integrated facility technology.

As Exhibit 6-16 on the next page describes the evolution of IWMS, the trend has been toward the breaking down of functional silos within an organization and the creation of business intelligence.

At first, facility management departments used discreet (not integrated) software applications to manage specific tasks, such as managing a construction project or real estate leases. The first CMMS reflect this approach.



Exhibit 6-16: IWMS Stages of Evolution



Source: Adapted from Daniel O'Toole. "2009 Integrated Workplace Management Systems Market Perspective and Outlook." IWMS Connect, media.ifma.org/fmtoday/2009IWMSMarketPerspectiveandOutlook.pdf.

As organizations began to focus on achieving greater productivity and increasing the enterprise's value, space management processes became more integral to the organization's success. After all, facility space and operation comprise the second largest line item in most organizations' budgets, after human resources. CAFM introduced applications aimed at improving the knowledge of how space was being used and the ability to use space more efficiently.

The IWMS stage of this evolution aims at integrating building data throughout the organization—not just the facility—to support the organization's business strategy. IWMS can be used to analyze the total value of a certain property and manage it for its greatest potential over its life cycle. This data is available in real time to senior management to support decisions and provide accountability to stakeholders.

As business trends emphasized accountability and metrics, IWMS has become a key way for the organization, rather than just a single department, to measure its performance. For example, being able to calculate true total cost of occupancy could allow an organization to improve its leasing decisions, invest in infrastructure that lowered costs (e.g., raised floors to accommodate wiring and cabling, flexible signage), and manage costly activities, such as churn. This would require, however, capturing all relevant costs over an extended time period.



IWMS concept

IWMS allows facility managers to consider costs and other outcomes over the entire life cycle of a project, space, building, or system—from planning and construction through operation to decommissioning—and to manage from a more holistic perspective. The value of the facility is not merely the assessed resale amounts of its physical assets; it also includes how well the facility uses those physical assets to accomplish the organization's strategic goals. Is the facility used in the most productive manner? Does the organization have the right kind of space at the right time in the right locations? To accomplish this assignment, IWMS integrate data from all corners of the organization, crossing—and breaking down—the functional silos.

As Exhibit 6-17 on the next page illustrates, key to the concept of IWMS is the sharing of information from separate databases so that it can be used across the organization. Information may be graphic (such as CADs, flowcharts, scanned images) and alphanumeric (such as spreadsheets, histories, documents) data. Information may reside in:

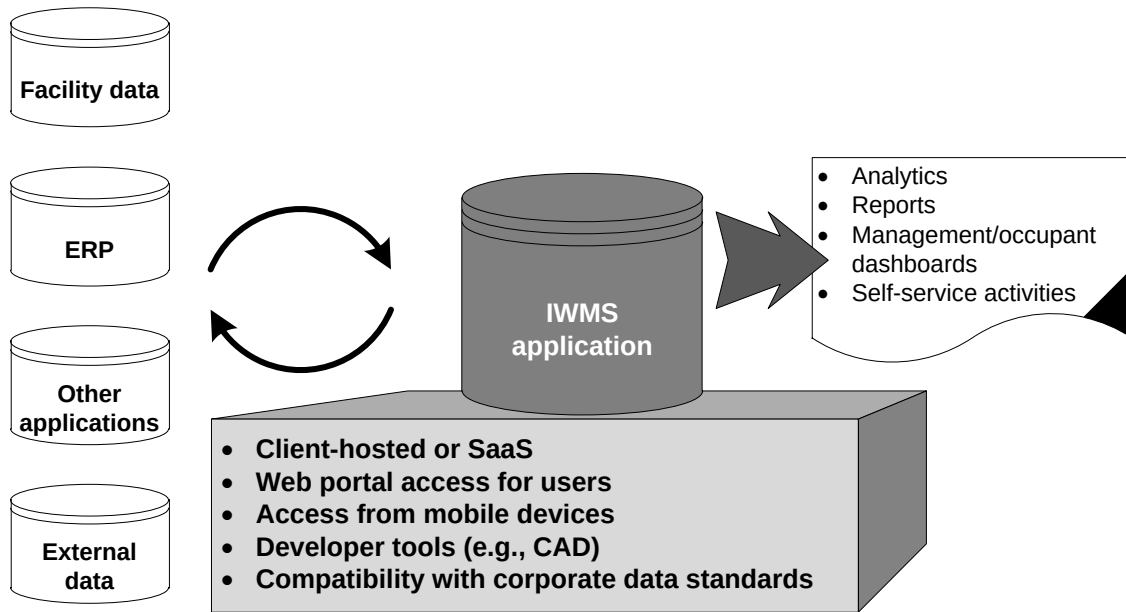
- Facility databases, including information such as facility assets, computer-aided design (CAD) images, performance data, event histories, warranty information.
- ERP databases. This data could describe strategic objectives, provide budgets and forecasts, track project cost and schedule data, define current employment numbers and per employee costs, document vendor information, or detail business continuity plans.
- Other special-purpose applications.
- External databases, used, for example, to convert currency or document local legal and regulatory compliance.

An effective IWMS may be either client-hosted (installed in FM computers) or SaaS. It allows access through a user-friendly Web portal, which allows remote users to access the system through mobile devices such as smartphones or notebooks. Many products include tools, such as CAD software, GIS and graphics applications that can be used to create dashboards that display system data in a meaningful way for designated audiences. Probably the most important feature of IWMS products is the use of data standards that allow integration of the IWMS with other organization systems, such as the ERP.

Exhibit 6-17 shows the variety of outputs that an IWMS could include.



Exhibit 6-17: IWMS Shared Data Approach



IWMS benefits for FM

Today IWMS is a strategic management tool that provides FM with:

- **Transparency.** Data can be analyzed to show how well FM is performing on the entire range of strategic goals—financial, operational and sustainable goals.
- **Control.** FM can account for its assets, their use and their return on investment. The organization can analyze its vulnerability to various risks more accurately and manage complex outsourced relationships.
- **Agility.** Data can support faster and better decisions. Business continuity plans can be implemented and updated quickly.
- **Flexibility.** IWMS applications can be tailored to organizations of different sizes and business types, including global organizations using different language and dealing with multiple currencies and exchange rates and with unique local legal requirements. Systems can also accommodate an increasingly mobile workforce.
- **Compliance.** Applications track required data and generate necessary reports in a timely manner. Many real estate IWMS, for example, ensure

compliance with the requirements of the Financial Accounting Standards Board (FASB) and International Accounting Standards Board (IASB).

- **Quality improvement tools.** The trend in IWMS is to build applications around process blueprints that can be considered best practices—a practice that can improve and standardize organization performance.

IWMS: Project management

IWMS applications can manage organization-level capital improvement budgets, supporting management decisions on how to allocate resources and providing transparency about the degree to which a project has achieved its various goals. They can also help users plan a project, allowing them to use project histories to estimate costs and schedules and to test different scenarios. During the implementation phase, the system tracks schedules, achievement of milestones, labor and cost budget, and vendor issues. Team managers have access to common documents, and the application controls document versioning. At project close, the system can support an analysis of the project execution against its original objectives and parameters. Stored information provides an opportunity for institutional learning to be applied to future projects. Vendors can be given access to the system to perform various activities, such as entering progress or supply orders.

IWMS: Real estate management and administration

A real estate portfolio management application performs on strategic and tactical levels. It can support development of strategic goals in real estate management, define appropriate metrics and visually present performance against these key performance indicators (KPIs) in a dashboard. This information can then be used to implement decisions based on the organization's strategies (e.g., dispose of inefficient properties). Some systems can evaluate real estate portfolios, identifying underperforming properties and suggesting alternative strategies. Systems can support improvement by implementing efficient workflows and benchmarking improvement efforts.

On a tactical level, the IWMS:

- Manages property-related documents. Missing documentation at the time of property sales can directly impact a property's sale price.
- Organizes and tracks lease and agreement details.
- Communicates agreement details to FM and other parties.
- Supports reporting for tax and other compliance purposes.



At any point in time, a facility manager can access the most current information about a particular property, as well as its history.

Did You Know?

One IFMA member uses an IWMS to manage 800,000 sq. ft. (about 74,000 square meters) in nine **different** locations. The organization struggled with the accuracy of its space utilization reports, their timeliness and the amount of time it took to create the reports. In the five years after implementing an IWMS, the organization saw the following results:

- A 2.5 percent reduction in vacancy rate
- A 1.25 percent increase in space utilization rates
- Better lease administration—no critical dates missed in five years, 1 percent savings by better matching of payments to obligations

The estimated cost savings over those five years? US\$5 million.

IWMS: Space and facility management

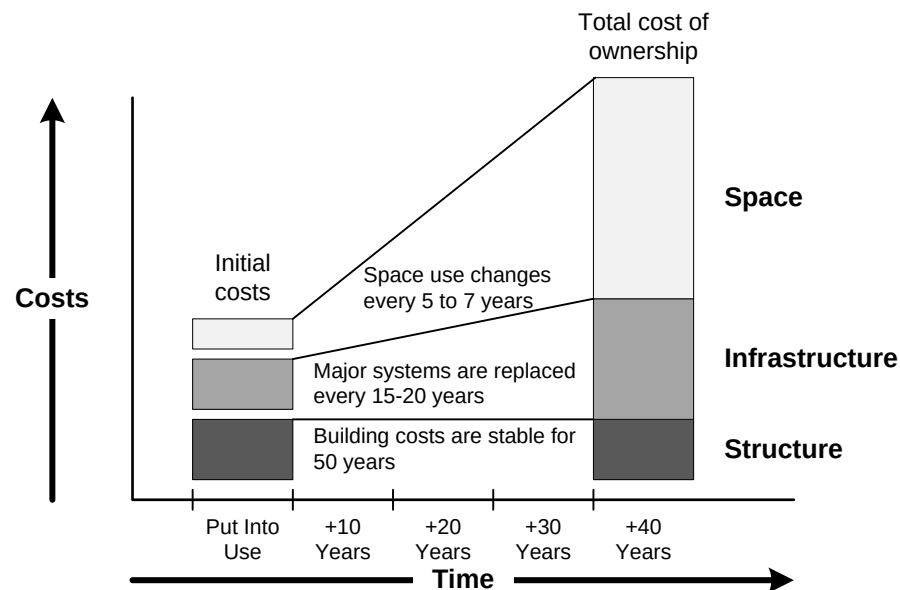
Exhibit 6-18 on the next page represents a composite of data from a study of fifty facilities. Operational costs represented the smallest share of new building costs for these facilities, but, in the course of the facilities' life cycles, those costs represented an increasingly large share of a building's capital outlay. Within twenty years the cost of space had outpaced the cost of maintaining infrastructure. These facilities were not a balanced cross-section of facility types, but the essential message of the data applies to all facilities. Under-utilization of space should be a major concern for FM, because it is common and becomes increasingly expensive for organizations over time.

IWMS space utilization applications help FM manage space and its associated costs better by using facility and ERP data to:

- Analyze use of space and assets throughout the organization.
- Align patterns of use with the organization's strategic goals.
- Plan for future needs by applying business forecasts to project space needs and best use.

The IWMS identifies opportunities to increase usable space, to allocate space in a more productive manner and to use space more efficiently. Data about space use can be analyzed to assess how assets such as meeting rooms and unassigned desks are being used and to determine appropriate space costs for chargeback or internal leasing purposes. Organizations may discover that space use becomes more efficient when business units must include space in their budgets.



Exhibit 6-18: Life-Cycle Facility Capital Costs

Source: Joachim W. Hohmann, Geoff Williams and Michael May. *Facility Automation: Between Myth and Mythology*. IFMA World Workplace, 2008.

The systems can also support planning (e.g., through CAD applications that can illustrate proposed floor plans) and efficient reconfiguring of spaces—applying organizational standards for space use.

The self-service capability included in many IWMS products allows occupants to perform many tasks themselves—requesting services (e.g., moves, new occupants or occupant departures) and reserving space for hoteling, parking or meeting.

For moves, the application:

- Applies space standards.
- Manages inventory of furniture and equipment.
- Issues bar codes or labels for more efficient moves.
- Coordinates with moving services and other service providers needed to prepare the new area (e.g., signage, IT).
- Coordinates with security for necessary keys or access control measures.
- If appropriate, charges back to departments or tenants for services and spaces.

Occupants or departments can reserve resources, such as meeting rooms, temporary workstations or parking space. The system can apply an agreed process (e.g., first come/first served) and can charge for the space use. This can increase



the efficiency of space management by encouraging occupants not to reserve space that they will not be using, since the system will charge for all reservations that have not been cancelled and released for use by other occupants.

From a safety and security perspective, IWMS applications can control access and share data with facility security so that visitors can receive appropriate clearances. IWMS applications can inform occupants of the location of the closest exits, emergency/first aid equipment and assigned assembly areas in the event of facility evacuation.

Asset and maintenance management

The first CMMS systems are several decades old. They were designed to run on mainframe computers to manage the maintenance of significant mechanical assets—typically in a plant setting. These CMMS essentially automated what had been a manual work order process for scheduling planned and unplanned maintenance activities. (For more information about managing maintenance activities, see the *Operations and Maintenance* competency.) They also included a register of all assets enrolled in the maintenance program. They were stand-alone programs that served single functions, departments or facilities.

In the 1990s enterprise asset management (EAM) systems were developed to serve organizations that had different types of facilities, equipment and processes. They provided a consolidated inventory of equipment and parts, integration with accounting and supply chains and standardized processes. These systems could run on a common platform and consolidate data across functions and locations.

Better network equipment and communication over the Internet have made the differences between CMMS and EAM harder to discern. Some IWMS manufacturers now include integrated CMMS products; others offer similar functionality in EAM. What they have in common is a goal to manage an asset's value over its entire life cycle—a task that requires integration of data from various sources and the ability to analyze that data and generate different types of reports. Combined with mobile technologies such as radio frequency identification (RFID), which is discussed in the next chapter, IWMS asset management applications can provide greater control over the organization's more portable assets. These assets can be checked in and out and located quickly.

Like other IWMS products, asset and maintenance applications have strategic and tactical uses.



From a strategic perspective, they can help FM:

- Document and track the value of the organization's assets and take steps to maintain or increase that value. Assets can be tied to the most current condition descriptions.
- Provide greater security for valuable assets, including both physical assets and documents or files representing intellectual property.
- Track volume of work and create more accurate work supply forecasts.
- Allocate and track costs to specific assets to identify issues (e.g., through failure reports) and support decisions.
- Create metrics aligned with the facility's strategic plan and evaluate actual staff performance against these metrics.
- Improve maintenance processes by defining necessary schedules, expertise, tools and supplies.
- Prioritize use of resources by assessing facility assets that need repair or replacement or are underperforming and by estimating response costs.
- Ensure compliance by generating audit trails for the handling of regulated materials, such as hazardous waste or controlled substances. The application can also support compliance with data privacy laws by creating audit trails for documents such as personnel files. It can also document completion of required inspections and maintenance.

On a tactical level, the system can help manage and track specific projects and automate planned and unplanned maintenance tasks. Automation of these tasks reduces time and expense associated with maintenance management, improves response times and extends the lifespan of facility equipment. Some systems include self-service capabilities that allow occupants to report facility issues, often through an online portal. The system will associate the request with details about the space in question, so that facility management can verify that the request is covered under any applicable service agreements. And all data is stored and available for further analysis, ensuring that facility management activity is fully documented and its performance completely transparent. Because the systems allow mobile interfaces, technicians can interact with the system at the job site. They can, for example, check on the availability of parts and place orders with suppliers as needed. They can also engage directly with manufacturers' technical support, sending data or images from the site.

Because the systems integrate accounting, warranty, service agreements and lease data, responsibility for repairs can be quickly assigned so that work can be scheduled and billed appropriately and warranty claims filed.



Sustainable facility management

An environmental management application in an IWMS helps:

- Create and track performance toward objectives for sustainable facility management.
- Support management of sustainable projects, such as system commissioning, ergonomics improvements, asbestos remediation, tracking and abating hazardous materials in the facility or lighting system upgrades.
- Capture and report data to measure sustainable performance in energy and water use (e.g., carbon and water footprints), indoor environmental quality and materials purchasing, recycling and disposal.

Sustainable objectives are often included in organizations' strategic plans. They may be related to supporting a carbon cap-and-trade system or to documenting compliance with voluntary and mandatory emission levels and/or resource management mandates. Facilities may also need to document energy performance to qualify for energy provider rebates or discounts or to support applications for sustainable certifications (e.g., Leadership in Energy and Environmental Design [LEED], Building Research Establishment Environmental Assessment Method [BREEAM], German Society for Sustainable Construction [DGNB] or Green Star Australia). IWMS applications can generate the necessary reports with the required data.

Purchasing an IWMS

As with implementing a BAS, the decision to implement IWMS represents a considerable investment of organizational resources and facility management manpower. Because of this, experts advise that facilities new to IWMS take advantage of the way IWMS vendors bundle automated applications and test the technology to solve one or two of the organization's most serious "pain points." If successfully implemented and integrated into the organization's culture, IWMS use can be expanded.

Facility managers should also consider purchasing IWMS as software as a service (SaaS). Although this requires budgeting for ongoing subscription costs, this approach has two possible advantages:

- It may accelerate implementation and allow the project to begin showing return on investment sooner.
- SaaS may ultimately be the less expensive alternative. One IWMS ratings service estimates that upfront license and maintenance costs may be only 25 to 50 percent of the actual cost of an IWMS, once it has been implemented and integrated with enterprise management systems.



In choosing an IWMS, the facility manager must first ensure that the system will comply with the organization's IT standards. Again, partnering with IT is essential, and IT should participate in IWMS selection.

As with choosing a BAS, facility managers should begin the process of choosing an IWMS by focusing on what the organization needs and how those needs are prioritized by management. Beyond these needs, facility managers should consider the features that the systems under consideration include and how well these features are implemented by the manufacturer. Important features to consider include:

- User-friendly and intuitive interfaces that are easy to learn and use.
- Level of integration between databases (which may have different environments).
- Speed of transactions.
- Multiple clients capability.
- CAD integration.
- Browser-based tools.
- Ability to assign different internal security access levels.
- Workflow modeling capability.
- Document management to allow multiple users to comment on and amend project documents.
- GIS functionality. This is useful for organizations with multiple buildings, structures and/or locations.
- Enterprise portal compatibility.
- Role-based Web portals. This allows users to access the system through a Web portal that is tailored to the way they use system data and applications and the appropriate security levels.
- Analytics for different purposes, such as trending analysis for predictive management and ability to test scenarios.
- Reporting tools, including dashboards.
- Wireless access.
- 24/7 customer support.

Purchasing: An IWMS case study

The following case study summarizes a business case prepared to support a funding request for an IWMS-related project. The organization is a global agricultural corporation, with numerous types of facilities.



IWMS Case Study

FM in one region of a global organization requested funding for planning an IWMS to replace an existing 10-year-old CAFM system. The project scope included researching organizational needs to establish detailed user requirement specifications and describing the optimal procurement process.

The sponsors noted the following in support of the project:

- A major planned refurbishment project could be completed only with an IWMS.
- Delay in IWMS implementation would increase risk and financial loss in the event of a CAFM crash.
- Major benefits of acquiring an IWMS included cost reduction in system operation and facility management and better integration into the existing information system.
- Additional benefits would result from:
 - Advanced facility services outsourcing tools.
 - The ability to transform a system used by only a few personnel into a standardized tool that could be accessed by a broader user base.
 - Support of increased compliance requirements and regulation by providing more accurate and timely building operation documentation.

The proposal included a 14-month schedule for design review, design of system requirements, building and testing, and implementation. Budgeting occurred in two phases: US\$80,000 for design and US\$400,000 for delivery of the IWMS.

Special point: The sponsors noted that the organization would own all data.



Progress Check Questions

Directions: Read each question and respond in the space provided. Answers and page references follow the questions.

1. The benefits of automated facility technology include which of the following? (*Choose all that apply.*)
 - ☐ a. Decreased operating costs
 - ☐ b. Lower job requirements for technicians
 - ☐ c. More efficient facility management processes
 - ☐ d. Decreased need for IT in facility management processes

2. Which of the following best describes a BAS? (*Choose one.*)
 - ☐ a. One-way control mechanism for multiple core building systems
 - ☐ b. Energy-efficient tool to operate HVAC systems
 - ☐ c. System supporting full communication between controllers and devices, automated decisions and analysis
 - ☐ d. System that integrates various facility management functions, including building control and facility space utilization

Link the following terms on the left with the appropriate description on the right.

- | | |
|-------------------------------------|--|
| 3. _____ Middleware | a. Open communication protocol |
| 4. _____ BACnet | b. Enables greater integration with enterprise data |
| 5. _____ Client-server architecture | c. Cycle of input, processing, output |
| 6. _____ Closed loop | d. Software designed to integrate devices from different manufacturers |

7. List at least four capabilities of a BAS.



8. Which component in a BAS architecture manages communication between the user and devices?

(Choose one.)

- ☐ a. Graphic user interface
- ☐ b. Controller
- ☐ c. Sensor
- ☐ d. Supervisory network

9. A facility manager would like to be able to access BAS in each building of a widely dispersed campus, no matter where the facility manager might be. What feature in a BAS would enable this action? (Choose one.)

- ☐ a. Graphic display capabilities
- ☐ b. Web browser
- ☐ c. Use of IP
- ☐ d. Communication with remote sensors

10. List at least three uses for the information and analysis provided by an EMS.

11. What is the purpose of demand-management tactics in an EMS? (Choose one.)

- ☐ a. Reduce overall energy consumption throughout the facility.
- ☐ b. Shut down energy-intensive processes on an automated signal.
- ☐ c. Lower the rate at which a facility is consuming electricity at peak times.
- ☐ d. Identify areas that are consuming the largest amounts of electricity and project optimal levels.

12. Which if the following best describes the relationship between a BAS and an IWMS? (Choose one.)

- ☐ a. A BAS may contribute data to be used by IWMS applications.
- ☐ b. A BAS requires an IWMS to integrate core building components.
- ☐ c. The two perform similar functions but at different levels of enterprise integration.
- ☐ d. An IWMS application cannot be implemented unless a facility has a BAS.

Link the IWMS application on the left with the deliverable described on the right.

- | | |
|------------------------------------|--|
| 13. _____ CMMS | a. Energy impact of new cooling system |
| 14. _____ Space utilization | b. Weekly technician task schedule |
| 15. _____ Portfolio management | c. Move management |
| 16. _____ Environmental management | d. KPI comparison of properties |



17. A facility manager is reluctant to invest in an IWMS because it is possible that the organization will be acquired by a larger corporation in the next five years and will expand significantly. At the same time, the facility manager believes that having quality facility data from an IWMS could contribute toward more favorable negotiations during an acquisition. What IWMS feature would serve this organization's purposes? (*Choose one.*)
- ☐ a. Customizable online portals
 - ☐ b. Analytics capabilities
 - ☐ c. Limited interoperability
 - ☐ d. Availability as SaaS



Progress check answers

1. a and c. Automation can lower operating costs because it provides more precise control. Automation can also make effective processes more efficient, improving communication and diffusing information. It will increase the knowledge and skill requirements for technicians and probably increase collaboration between facility management and IT. (p. 6-35)
2. c. A BAS provides two-way communication between controllers and devices, automated decisions and analysis of stored data. (p. 6-38)
3. d (p. 6-33)
4. a (p. 6-33)
5. b (p. 6-34)
6. c (p. 6-33)
7. BAS capabilities may include:
 - Real-time information about the performance of system components
 - Alarms to indicate deviations beyond determined parameters
 - Energy-saving actions, such as scheduling, sequencing or lockout
 - Performance of complex integrated processes (e.g., demand-controlled ventilation)
 - Duty cycling to prevent excessive wear on individual components
 - Trending/analyzing data to support commissioning reports, repair/replace decisions, business cases (p. 6-38)
8. d. The supervisory network enables communication between the user/servers and the controllers that are, in turn, communicating with devices, applications and sensors. (p. 6-40)
9. b. A BAS with a Web browser would allow remote access over the Internet. (p. 6-43)
10. Information and analysis provided by an EMS can be used to forecast use, identify opportunities for energy conservation, test energy strategies to determine cost-effectiveness, create baselines for diagnosis of equipment problems, verify service level agreements with energy contractors, commission new equipment or systems and comply with local laws and regulations. (p. 6-45)
11. c. The purpose of demand-management tactics is to lower the consumption rate of electricity during peak pricing periods. The tactics themselves may include shutting down or rescheduling processes or identifying problematic areas or systems. (p. 6-47)
12. a. An IWMS integrates data from facility systems and enterprise systems. (p. 6-51)
13. b (p. 6-56)
14. c (p. 6-54)
15. d (p. 6-53)
16. a (p. 6-58)
17. d. Purchasing IWMS capabilities as SaaS gives the facility manager flexibility by not tying the facility down to a system it may outgrow quickly. However, it also provides more integrated data that can improve facility management and demonstrate value to potential new owners. (p. 6-58)



Chapter 3: Emerging and Evolving Facility Technology

After completing this chapter, students will be able to:

- Describe how the following technologies function:
 - Building information modeling (BIM)
 - 3D imaging
 - Thermal scanning
 - Geospatial information systems (GIS)
 - Bar codes
 - Radio frequency identification (RFID)
 - Show how each of these technologies can be used by facility managers to align facility management processes with stakeholder interests.
 - List factors facility managers should consider when evaluating acquisition of these technologies.
-

✦ Topic 1: Building Information Modeling

BIM overview

Although building information modeling (BIM) is computer-based, it is not a specific software application. It is an intangible approach to—as well as a methodology and process for—managing all knowledge about a building and its operations, across its entire life cycle. It uses graphic tools such as three-dimensional (3D) CAD and analytic software to create synergy among discrete pieces of information stored in commercial databases. The National Institute of Building Sciences defines BIM as:

a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward.

Technically, BIM is not a new emergent technology since the term's use dates to the 1980s when Robert Aish applied a multidisciplinary approach to redesigning a Heathrow Airport terminal. Since then, however, the methodology has followed the sometimes slow path of the diffusion of technology: from innovators to early and late adopters. A



survey of contractors in the U.S. and Europe showed an adoption rate of 49 percent in the U.S. in 2009 (up from 28 percent only two years earlier) and 36 percent in Western Europe in 2010. (There was no previous adoption data for Western Europe.) Although the adoption rate is lower in Western Europe, the contractors who do use BIM use it very intensively, and they report expectations that future use will surge.

At first, BIM remained of primary interest to architects and builders, rather than facility management. Because of growing interest in the totality of facility life-cycle costs—rather than a tight focus on initial construction costs—a competent facility manager should become familiar with BIM.

This topic begins with an overview of BIM itself and then focuses on the advantages BIM offers across the facility life cycle, including both the planning and construction phases and facility operation and maintenance. The advantages will show clearly why facility managers should try to become involved in an organizational construction project when the possibility is first discussed, before the project is on the drawing board. Beyond the fact that BIM will enhance the design and construction process, using BIM helps ensure the availability of the building data facility managers need to make the best use of other facility technologies. Facility managers can be champions of a technology that can benefit the organization from design through the decommissioning of a structure, supporting better decisions and providing greater transparency.

BIM definition

In the term *building information modeling*, the word *model* must be understood from two perspectives:

- As a 3D representation of a structure
- As a representation of a logical system with certain principles and processes—how the components behave (A model makes it possible to detect potential faults and predict performance.)

The distinctive capability of BIM is to use both the model of the building's structures and the building's logical models to manage the details of the facility's systems—to see points of intersection and conflict.

BIM allows this because it is not merely a three-dimensional image. BIM starts with 3D CAD, which is simply a geometric representation of a



building, but then proceeds to layer over this 3D picture with additional digital data that tells much more about the structure than dimensions and spatial position. BIM tools use parametric objects (e.g., walls, doors, floor, windows) that have defined attributes and rules. Object attributes could include dimensions, geospatial location, physical properties (e.g., material, color, texture, acoustic characteristics, energy performance), age and cost. Object rules allow the objects to fit themselves into a model without exceeding certain parameters. For example, a door will fit into a wall, and the wall's relationship to the floor and ceiling will be modified, but only within allowed parameters. Object rules alert users whenever they are violated by a specific design order—"clashes" or "collisions" of building elements. Clashes can be both physical, functional and compliance-related. They can indicate, for example, that a design does not meet certain energy performance rules, that weight changes will require additional support or that a proposed change violates building codes.

Object information can be accessed by all those involved in constructing and operating a building, including contractors. Information can be viewed in various ways—not just as a 3D image but as alphanumeric tables that contain data that enables analyses and simulations. Objects are non-redundant: when an object is changed, that change applies to the object in any view.

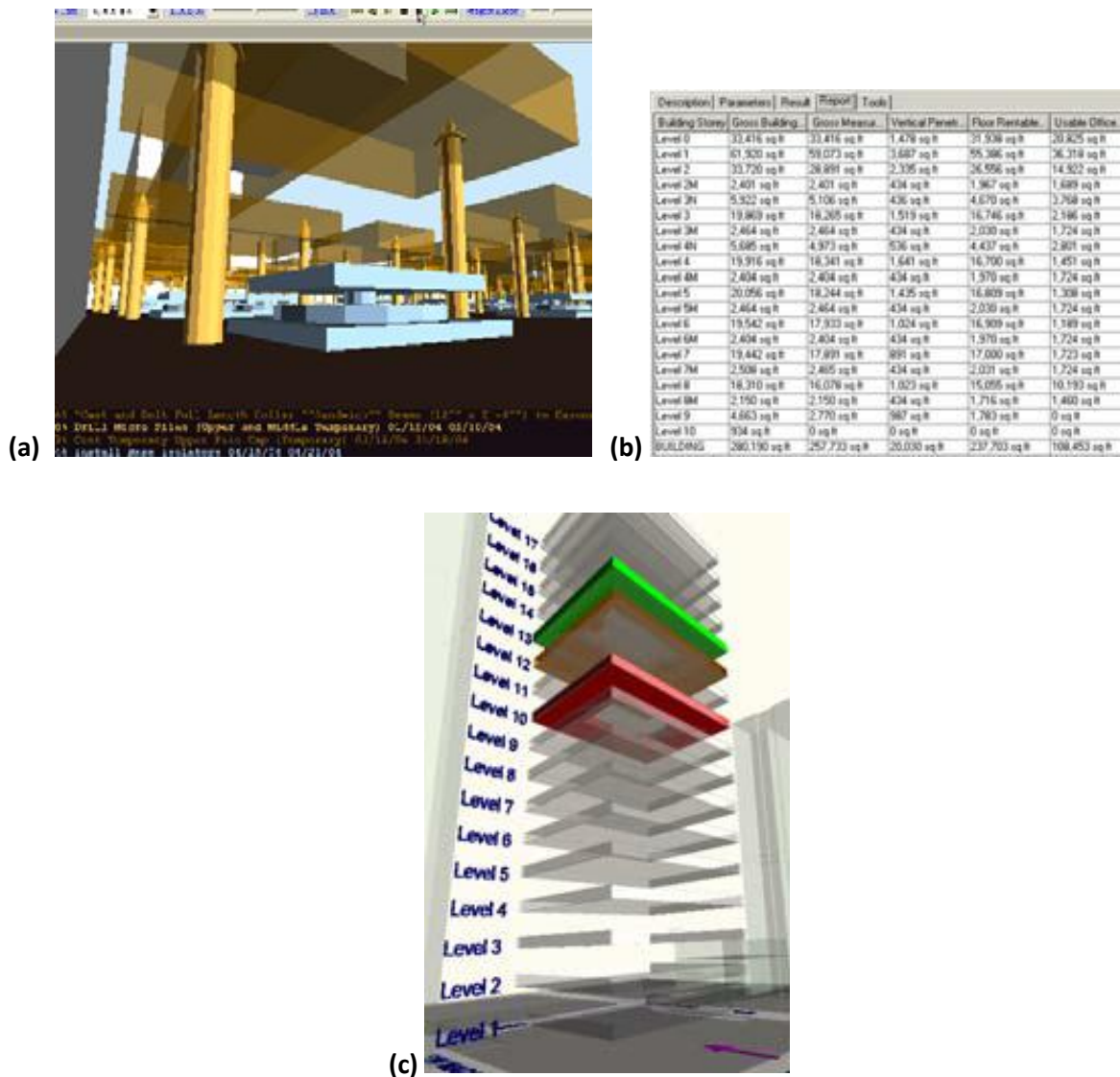
Finally, BIM is also a 4D image, adding the element of time. Construction activities, contractors and subcontractors, and supplies can be indicated for each phase of a project as it proceeds. The impact of current decisions on future performance and requirements can be extrapolated. If BIM data is maintained over time, post-construction changes can be captured as well.

Exhibit 6-19 on the next page shows data from a U.S. General Services Administration (GSA) pilot project that used BIM. The data can be viewed as a 3D object (a), a spreadsheet showing space by different categories for each level of the building (b) or a 4D image, indicating where a project is at a specific point in time (c).

From an FM perspective, BIM can be particularly useful because it has the potential of providing the data FM needs to manage properties more effectively and efficiently. The goal with the BIM process is that building information can be turned over at commissioning and used to populate building systems, such as IWMS.



Exhibit 6-19: GSA BIM Project

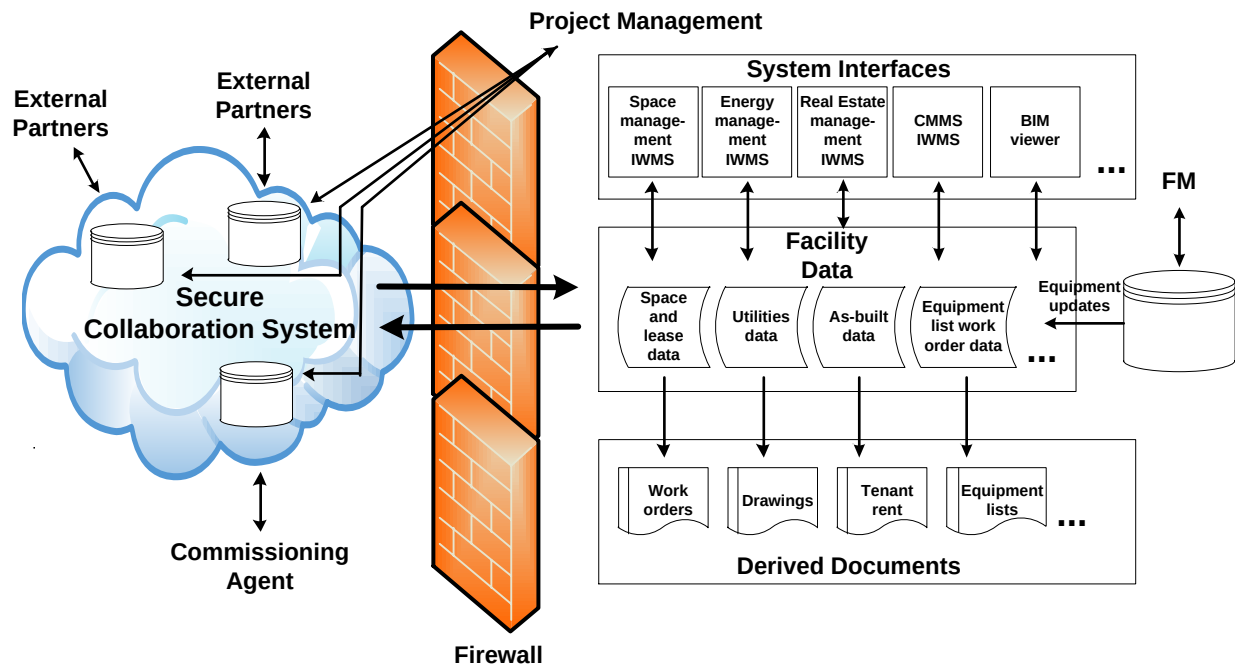


Source: GSA BIM Guide Series 01.

Exhibit 6-20 illustrates BIM’s relationship to existing enterprise and facility systems. During a project, FM can make certain facility data available to external contractors. When the project is complete, data compiled by internal personnel and external contractors is added to FM data. The data is then available to facility technologies, such as IWMS and BAS, to perform analyses and processes essential to the organization—such as generating work orders, drawings, space charges and equipment registers. Throughout the building’s life cycle, FM maintains building information data, adding and decommissioning equipment.



Exhibit 6-20: BIM in Facility Life Cycles



Source: Based on GSA BIM Guide for Facility Management. December 2011, www.gsa.gov/bim.

BIM advantages

In an article in *Facility Management Technology*, Louise Sabol listed the benefits of BIM during the planning, design and build phases, including:

- Earlier decisions, since planners and designers can test designs to see if they generate the desired building performance and adjust designs accordingly.
- Improved accuracy of shared information among all team members, which decreases the chances for misunderstandings, especially in teams speaking different languages. All team members can access the same data.
- Rapid quantification to support calculation of cost estimates and development of project schedules.
- Robust analytics to keep the project aligned with its energy performance and space use goals, to schedule and sequence project steps and to prevent costly mistakes through clash detection. Clash detection software identifies potential conflicts among a building's plumbing, ductwork or electrical systems—preventing tear outs and redesigns before the problem occurs.
- Improved project delivery with clear and accurate documentation of the entire project, but in particular the building's parameters as delivered. This will facilitate building commissioning.

In addition, using BIM to guide a construction project will reduce the schedule and decrease risk (e.g., failure to comply with local codes, litigation stemming from poor communication and documentation of decisions). It will reduce the number of change orders (and their associated increased costs) because the modeling displays interference and conflicts that can be addressed and avoided by redesign. It will improve the quality of decisions along the way by making it more possible for decision makers to test ideas and weigh possible outcomes. Organizations can also implement standards in a uniform way. For example, when the effectiveness of a team process depends on a particular use of space—for example, in hospital operating rooms, wet labs or collaborative meeting rooms—BIM can ensure that the template is faithfully applied to the construction project.

During the operation phase of a building's life cycle, BIM can be used to:

- Populate the various facility management databases. This can help facility management meet one of the more serious challenges to implementing IWMS—the burden of entering accurate data and maintaining it. The level and quality of automated decisions depend on the amount and quality of the available data.
- Visualize difficult to see areas, such as a plumbing leak in a pipe hidden behind walls. This can help staff identify and repair sources of problems more quickly.
- Use real-time data from BAS sensor networks for better analysis of building performance. This data can fuel energy analytics on large and small levels—from whole buildings or floors to individual cubicles.
- Display a history of changes to a building element (e.g., the last time a wall was painted or carpet replaced). This can support implementation of lease agreements or analysis of facility products and processes.
- Translate facility actions into value to the organization by showing the life-cycle cost savings of purchasing certain equipment or retrofitting windows.

BIM challenges

In an article in the *Journal of Building Information Modeling*, Angela Lewis and Jim Whittaker noted five specific challenges that must be overcome before a facility manager can achieve the dream of “click[ing] a 3D object in a BIM and instantly hav[ing] current, user-specific asset data.” These are:

- **Redefining industry practices.** BIM is an opportunity to shift from reactive to proactive modes—from simply responding to problems as they arise to preventing those problems from occurring and taking advantage of resource-



saving opportunities. FM will have to obtain buy-in from all levels of the organization before BIM tools and practices are adopted. This will require that facility managers commit to educating themselves about these new practices, making training available to staff and educating management about the cost/benefit ratio of managing proactively. Facility managers may have to retool their staffs to take advantage of this technology—redefining expectations of staff, recruiting technologically adept personnel and ensuring training of existing staff.

- **Using facility technology effectively.** FM must focus first on the processes and then on the technology. Proposals to acquire technology should describe how the technology will be used, what data it requires, what outcomes it will produce and how the value of the investment will be measured. Another issue is the variability of information that organizations maintain about their structures and the completeness, currency and accuracy of the building construction data that the facility manager may receive at delivery. Best practices will have to be developed about what information must be maintained in a database about each property and how it will be maintained.
- **Planning for data integration.** Since data will be used by different people for different purposes, FM must consider the issue of data exchange. Standards are gradually emerging for BIM, but in the meantime, vendors are using open standards and data exchangers such as Construction Operations Building information exchange (COBie) and Specifiers' Properties information exchange (SPie). Currently, the buildingSMARTalliance, a council of the National Institute of Building Sciences (NIBS), directs a project to develop open standards and infrastructure to support the vision of BIM for all of those involved in a building's life cycle, including facility managers. Standardized CAFM data exchange tools that are compliant with the IFC (Industry Foundation Classes) of buildingSMART are already available.
- **Relating BIM data to business decisions.** FM must engage with management and provide what management needs—data upon which they can make sound business decisions. BIM tools can be used to create business cases that align recommendations with the organization's strategic objectives.
- **Managing cost of adopting BIM tools.** Lewis and Whittaker recommend that facility managers begin by integrating FM technologies and demonstrating the value of efficiencies created by integrating, for example, the facility's CMMS and BAS.



Implementing BIM

To get started in using BIM methodology, facility managers must first prepare by investigating the potential for system data integration and interoperability when buying new facility technology. Even if the facility manager opts to use a consultant to provide BIM services for a project, integration of facility data and systems will facilitate the project.

Projects should be carefully chosen since they will serve equally as a building project, a learning experience and the opportunity to begin developing the facility management practices that will be needed to support BIM implementation in the future. The project should focus on a business need or pain point, and the team should agree on metrics that reflect the desired outcome.

The following case study summarizes a GSA pilot project that integrated BIM with CMMS technology. While the project ran into many problems related to compatible data, it did produce best practices that would support future efforts in this area.

GSA Case Study

GSA Goodfellow Complex, St. Louis, Missouri

The goal was to create a BIM after construction by using the facility's CMMS and by converting 2D images into BIM data. Gaps were filled in by means of a thorough documentation review and an on-site survey. Records were created for over a thousand pieces of equipment. Because of inconsistencies between the model and the facility's CMMS technology, only the equipment's description and location fields were populated when data was extracted from the CMMS. Further, inconsistent location information and non-unique equipment identifiers contributed to a low match rate (17 percent) between the BIM and CMMS software.

Based on this experience, the BIM consultant recommended greater standardization and structuring of data in the two systems. Resulting best practices directed FM to:

- Create equipment families and types within the BIM tool to accommodate equipment variations.
- Define matching naming conventions for both the BIM and CMMS and requiring their use.
- Ensure that all information fields in the CMMS and parameter fields in the BIM were populated.



✦ Topic 2: Building Imaging Technology

Technology is being used to allow FM to capture data about building structures and to test building systems. This topic briefly describes the technologies and uses for 3D/laser scanning and thermal scanning.

3D imaging

3D imaging is a system in which beams of light (usually in the visible to near infrared spectrum) are rapidly reflected off specific surface coordinates on an object. A scanner captures measurements and plots the results to create a 3D representation of the object. Because the light cannot pass through solid objects, 3D imaging systems use multiple setups, scanning the surface or space from different angles.

The distance between the projectors and the object can range from one meter to one kilometer. The object can therefore be relatively small (e.g., a detail of a building's terracotta ornamentation that must be restored) or very large (e.g., a congested urban area). The surface does not need to be treated in any fashion. Because the application can analyze both the distance and the intensity of the light reflected from the object, the 3D image depicts both geometry and quality of materials.

Did You Know?

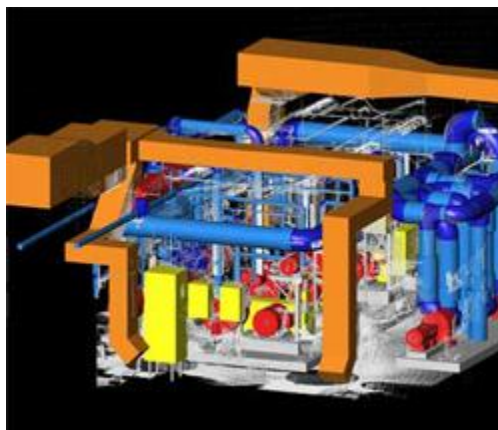
Laser scanning is an example of 3D imaging. It can be conducted within 900 feet of the target and is accurate to a quarter of an inch. The "point cloud" created during the laser scanning process can consist of more than 60 million points.

3D imaging is used to document existing structures. These records can be used to plan projects, measure space/volume more accurately, visualize hard to access areas such as mechanical spaces, audit contractor work, create accurate "as-builts," and support future restoration. For example, one company needed to install a refrigeration unit in an already crowded mechanical room. By scanning the room's interior, which took six projector setups but only one hour, the company created a detailed 3D image and saved about 65 percent of the project's schedule.

Exhibit 6-21 shows the scan results.



Exhibit 6-21: Laser Scanned Mechanical Room



Source: GKS Global Services.

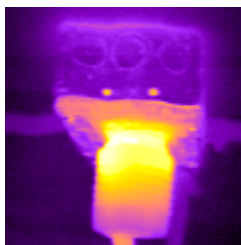
3D imaging has safety uses as well. Difficult to access spaces can be visualized to allow planning for maintenance or to prevent collisions during renovation projects. Security can be planned by analyzing spaces.

3D images can also be scanned into BIM to create models of existing structures and to update a building during its life cycle.

Thermal scanning

Thermal scanning or thermography is a technology that uses a special camera that converts the transmission heat in the area being photographed into electrical impulses. These impulses are then color coded by intensity. Exhibit 6-22 shows a thermal scan of an overheating wall plug.

Exhibit 6-22: Thermal Image of Wall Plug



Source: Fluke Corporation (www.fluke.com).

Thermal scanning is often used to inspect and perform maintenance on electrical systems since it can detect loose connections, overloads, imbalanced circuits or damaged equipment.



The most obvious benefit of thermal scanning is that it reduces the likelihood of a fire, but it also promotes business continuity and saves money by detecting problems early and preventing or minimizing facility downtime.

✦ Topic 3: Geospatial Information Systems

GIS overview

GIS is an intelligent graphic tool that maps data on a geospatial grid and enables analysis of this data for various purposes. The data is of three types:

- Vector data is digital information about the sizes and relationships between points, line and shapes. Vector data is what one sees in a two-dimensional CAD drawing. Imported into a GIS system, the vector data is overlaid onto geospatial coordinates that are aligned with cardinal directions.
- Raster data is images, such as aerial photos of a facility, which can be imported into the system as digital files (e.g., *.jpg, *.bmp).
- Attribute data is stored in a relational database, such as the IWMS or ERP databases. The GIS links vector data in the GIS with attribute data in the database. The links must be tested and maintained to ensure that the link functions and is accurate. Attribute data can take different forms—for example, a type of activity, age, occupancy level or condition rating.

The system can map lines (e.g., utilities) as well as points on those lines (e.g., specific valves). The points and lines can be organized into networks.

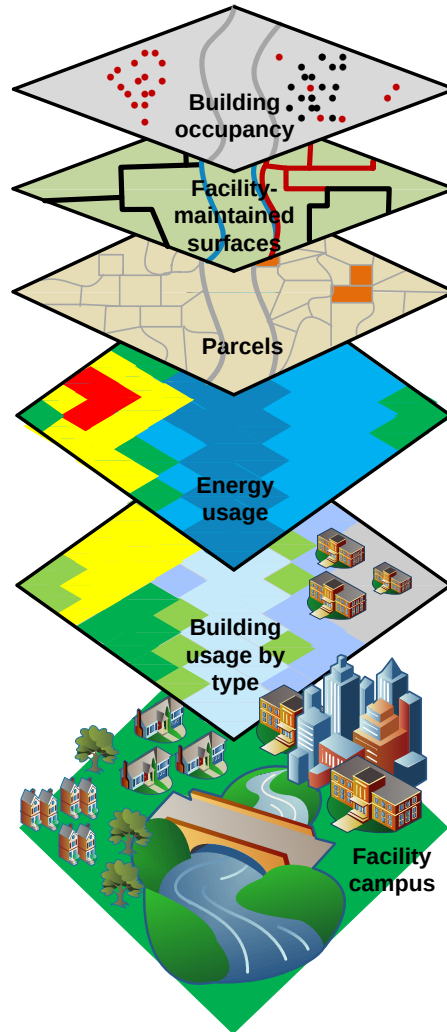
Exhibit 6-23 on the next page shows the different types of data that can be laid over the same physical space.

An optimized GIS can support strategic facility decisions by:

- Combining data from different sources—e.g., existing CAD, BIM data from design and construction, publicly available geospatial data maps (e.g., geodata.gov Web site in the U.S.),
- Integrating this data with information from the organization's BAS, IWMS and ERM system,
- Layering the data over a map,
- Analyzing it according to various factors and then
- Presenting a graphical result, so that a user can see certain characteristics of the facility's physical characteristics.



Exhibit 6-23: GIS Overlays



GIS can be sized on multiple levels—from a global perspective to a floor view. For example:

- On a global scale, an organization can locate its various facilities on a map and quickly and simply visualize differences in their key performance indicators—in space utilization, for example.
- On a local level, an organization can use GIS to analyze a proposed facility location in terms of proximity to largest customers, critical suppliers, critical transportation routes or employee addresses.
- On a campus or building level, GIS can show how space and energy is being used, how certain functions or departments are distributed throughout a campus or building, proximity to parking and other amenities and proximity to hazards as well as emergency exits or escape routes.



GIS analysis

Once data has been input into a GIS system, the data can be queried and analyzed in different ways to find:

- Amounts (e.g., number of parking spaces, number of trees that require pruning this season)
- Locations (e.g., all meeting rooms or class rooms that can accommodate more than 100 occupants, zones with amenities for disabled occupants)
- Proximities (e.g., the closest parking area to Building G, the closest service calls to where a technician is currently located)
- Overlaps (e.g., what functions of a given type will be affected within a defined construction zone or hazard area)
- Routes (e.g., the fastest evacuation routes for different sections of a campus, the location of an emergency assembly area, the time required to get from one facility to another in a distributed campus).
- Changes. Because GIS can include a fourth dimension—time—it can highlight changes that have occurred in the facility over a period of time, such as increases in building footprints or elimination of parking or changes in road layout.

Because GIS can associate data in different ways, it can also visualize workflows across a facility on a building or campus level. GIS can also support analysis by creating “what if” scenarios, showing the effect on transportation costs of locating in a particular area or potential conflicts created by locating a particular function in a certain area. It can also help establish staff assignments, schedules and work routes.

FM uses of GIS

GIS offers the following functionality for facility management:

- Real estate portfolio management
- Asset management
- Sustainable facility operations
- Increasing organizational productivity
- Emergency preparedness and business continuity

Real estate portfolio management

Many organizations today may want to consolidate or shed properties to decrease operating costs. GIS can help facility managers compare holdings according to performance parameters and total life-cycle costs to provide visual answers to questions such as:

- How do occupancy rates compare among properties? Are there underperformers in terms of occupancy rates or space utilization? Can organizational functions be brought back together under the same roof in some way?
- Where are costs of operation highest? What structures are least energy efficient? Which will require significant investment in upgrade in short- and long-range periods?



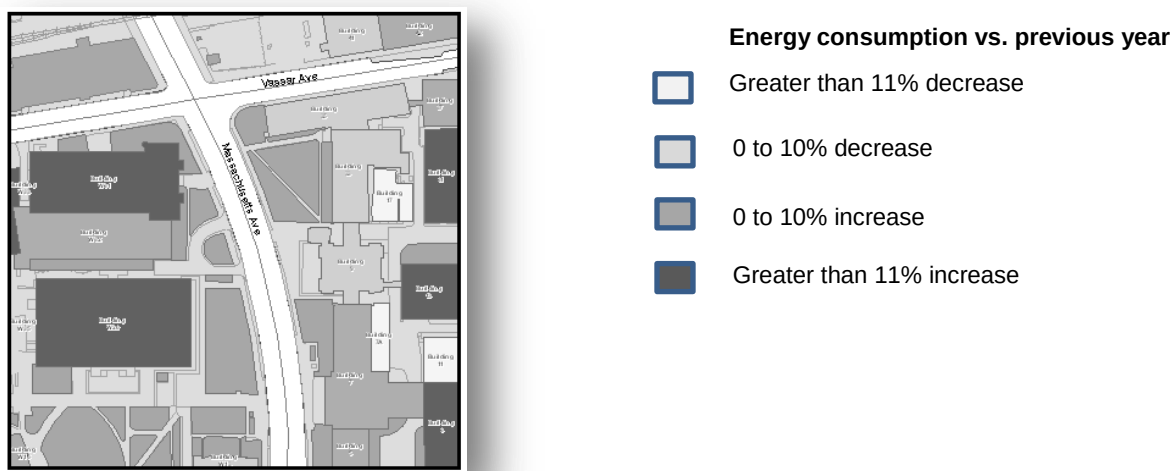
Conversely GIS can support siting decisions by placing facilities in their geospatial contexts:

- Which areas are trending upwards or downwards in terms of market values?
- Is transportation into and out of the facility adequate? What would happen if an event closed certain routes?
- What kinds of facilities are located nearby? How will they affect occupant comfort and safety, as well as organizational exposure to risk?

Asset management Linking assets to the GIS can help organizations identify assets more quickly if quizzed by regulators, insurers or boards. They can also identify certain types of assets more easily. For example, a campus learns that a disease is attacking a certain tree species in the area and knows it will have to budget and plan for removing and replacing a certain type of tree. GIS will streamline this process by counting and locating the susceptible trees. A scheduling for pavement resurfacing can be calculated more quickly and include as factors both surface conditions and priorities of adjacent operations. Ongoing projects and their phase of development can be identified throughout a building or campus.

Sustainable facility operations Performance of particular building areas or buildings on a campus facility can be combined with BAS data to display comparative energy performance, as shown in Exhibit 6-24 below. Other issues could be evaluated, however, if the relevant data is accessible, such as volumes of trash generated or occupant complaints about possible health hazards. The location of hazardous materials storage areas can be identified and shared with first responders and those who need to know this information.

Exhibit 6-24: GIS Map Comparing Levels of Energy Performance



Source: IFMA Technology Update.

Organizational productivity

GIS can improve productivity by lowering non-productive use of employee time—time spent travelling from one location to another or from a parking area to an office. Patterns of travel can be detected, and adjacencies improved. Since GIS can compare changes over time, systems can display shifts in population density within the facility throughout the day. This might affect location of parking areas, campus transportation amenities or the distribution and level of security. Buffer zones can also be shown, so that facility management can schedule construction projects with minimal impact on nearby operations or occupants.

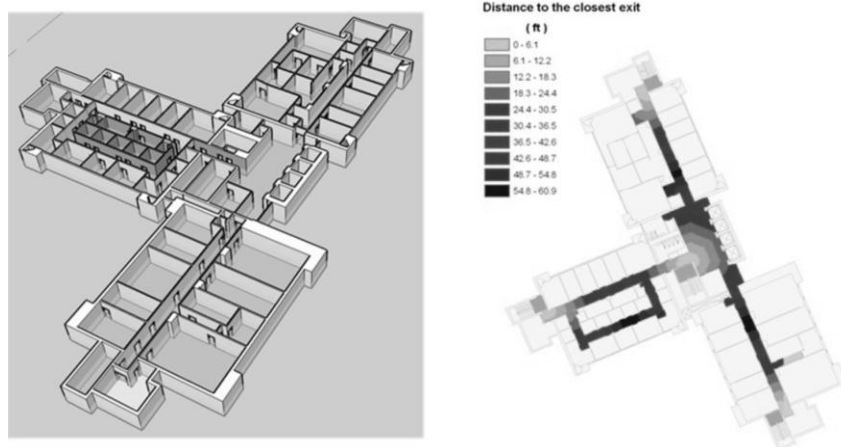
Emergency preparedness and business continuity

GIS can help facility managers identify issues to mitigate risks and respond to emergencies. For example, a GIS map that shows areas in terms of their use could show that a daycare center is located adjacent to an equipment area or hazardous materials storage area where the consequences of an explosion could be even more serious for the facility. A map showing egress points might be used to construct evacuation routes and automatic control of locked entryways. If the security system includes CCTV, the GIS could combine with that functionality to provide quickly a more complete picture of what is happening in a particular area during an emergency.

In terms of business continuity, locations designated as backup facilities can be located and networked for analysis and tracking. Supplies, agreements and other data can be associated with the sites.

Exhibit 6-25 is an example of GIS being used to analyze evacuation challenges on a floor.

Exhibit 6-25: GIS and Emergency Preparedness



Source: Prof. J. MacGregor Smith (MIE, UMass Amherst);
 “Geographic Information Systems (GIS) for Facility Management,”
 Houston, Texas: IFMA Foundation, 2010.



Implementing GIS

As with any new technology, cost will be an issue, and facility managers must prepare business cases to demonstrate return on investment. The initial upload of data into the system is also resource-intensive. GIS applications can be run as stand-alone systems, but they will be more useful to an organization if they can be integrated into existing IWMS, BAS and ERP platforms. This can be a challenge in an organization that has not integrated its databases and in a facility that is running separate applications to perform its various functions.

Integrating with legacy systems can also be problematic. Facility managers who are considering purchasing IWMS and/or BAS should consider the issue of integration with GIS as a purchasing factor.

✦ Topic 4: Automatic Identification and Data Capture

Definition

Automatic identification and data capture (AIDC) refers to a group of technologies that automate the collection of information from various sources. The group includes such technologies as the magnetic stripe used on credit cards or access cards, smart cards that are embedded with microchips that enable certain functions, and various biometric identification tools such as fingerprint recognition, iris scanning and voice recognition.

This topic will focus on two examples of AIDC that are widely used in FM: bar codes and radio frequency identification.

Bar coding is a good example of a technology that struggled to prove its usefulness. It took almost twenty years before bar coding was introduced in railway systems to track rail cars. Radio frequency identification has a similar history—growing out of technology used in World War II but not really taking hold until the 1970s, when the first devices were patented.

Both technologies have now, however, evolved into useful asset management tools for FM. Their methods are similar. An asset is tagged with an identifier, which can be read by a scanner and the data exchanged with a database. Their technologies, however, are different and create specific restrictions and advantages.

Bar codes

Bar coding is familiar to most people as the universal product code (UPC) symbol on packaged food and to most facility managers as the labels attached to furnishings and equipment. A bar code is a graphic representation of data that conveys information about the object to which it is attached. The



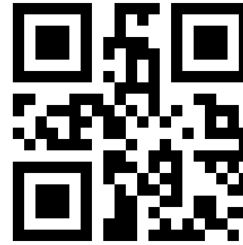
representation or symbol can be read by an optical scanner. This information is then transmitted to a computer, which accesses the associated data files and delivers this information to the user.

The bar code itself may be one-dimensional (1D) or two-dimensional (2D). 1D codes use a sequence of vertical, parallel lines of different thicknesses and with different spacing. 2D or matrix bar codes use geometrical shapes (e.g., squares and rectangles of varying sizes) arranged in different patterns within a larger square. 2D bar codes have somewhat different standards and capabilities and are discussed separately below. Exhibit 6-26 shows 1D and 2D bar codes.

Exhibit 6-26: Bar Code Types



Sample 1D bar code



2D code for King Abdullah
University of Science and Technology (KAUST)

Bar codes conform to regional and global standards. Users can create or outsource creation of their own codes from services. They can be printed locally according to the user's needs, with varying sizes and materials.

Scanning devices were originally specialized machines or handheld optical scanners, but scanning is now possible on a variety of devices, including smartphones on which applications have been installed.

Bar code uses in FM

Bar codes are used in FM in a variety of areas.

- **Asset and inventory management.** Most CMMS and IWMS include bar-code reading capability. This allows technicians to scan equipment codes into work orders, order or check out parts and track checkout of certain equipment and tools. FM can track inventory levels to identify opportunities for efficiency (e.g., to correct frequent out of stock conditions or high levels of inventory) and analyze individual work orders to develop typical requirements for similar orders.
- **Move management.** Bar codes are attached to boxes, furnishings or equipment. Movers can scan the codes to confirm destinations and to mark



progress toward the destination. FM can track the move and resolve issues more easily.

- **Access control.** Bar codes on identification cards control access to secure areas of the facility. Systems also allow tracking of access to support investigations in the event of losses. Bar codes on windshields can admit vehicles to authorized parking areas.

2D codes

2D codes can contain more data than a bar code and can be read by most smartphones equipped with free, downloadable reader software. One example of 2D bar coding is the QR (for quick response) code that is commonly seen in advertising. 2D codes can be created at no expense, using free downloadable software for various types of competing open codes. (There are proprietary codes as well, such as Microsoft Tags and Mobile Tag.)

Scanning the code with a smartphone can:

- Direct a user to a certain Web site.
- Display text and images—even streaming video.
- Send e-mails and messages.
- Dial telephone numbers.

As smartphones become more ubiquitous, 2D code use is growing and expanding into new areas. A 2011 survey by a marketing firm found that 2D code scanning grew by 4,549 percent from 2010 to 2011. Whether this particular technology will find a permanent home in FM remains to be seen.

Uses of 2D bar codes in FM

This technology is beginning to be applied in facilities, where it can be used to:

- Display equipment warranty information and contacts for service and parts.
- Connect staff over their phones to online manuals or tutorials about servicing a piece of equipment. Many manufacturers are now including these codes on their products.
- Encourage prompt reporting of facility maintenance problems by occupants. Occupants could scan a nearby code and be directed to a Web page for the facility CMMS. They could report lapses in cleaning or leaking plumbing in a restroom. A parallel code in the same area could then be used by staff to log a response to the issue.
- Invite occupants to link to and complete on the spot surveys, possibly increasing the response rate on occupant surveys.



Some other uses of 2D code have appeared that may be of interest in FM.

- Real estate companies use the images as a point of sale tool, to allow someone on site at an available property to link to additional information about the property. This eliminates delayed communication as brokers and potential tenants or buyers play telephone tag, and it helps screen buyers who may not want to pursue information beyond what is available automatically through the 2D code.
- Museums use 2D codes to connect visitors to additional information about exhibits. There is special potential here for visually impaired guests or non-literate guests who could access spoken messages over their phones.
- Some municipalities are using 2D codes outside buildings which allow users to view a building's history of code or permit violations.

Did You Know?

One educational facility places 2D bar codes on doorframes. Scanning the image links the user to the facility's Health, Safety and Environment system and Web site. The user can quickly identify the nearest emergency exit, the assigned assembly area in case of facility evacuation and other emergency-related information. This helps address the common challenge for FM—communicating emergency plans and information to all occupants, especially visitors.

Radio frequency identification

Radio frequency identification (RFID) technology is an automatic system that uses radio waves to locate both animate and inanimate objects. The system may include:

- Tags, such as those found on ID badges or cards.
- Readers.
- Servers with software applications.
- Enterprise platform with dedicated databases.

A tagged object is identified by a reader that communicates with a server. It may be a one-way conversation: the server simply notes and stores the transmission with other information, such as the location of the reader and the time. Or the reader may be capable of a dynamic, two-way conversation with the server. The reader transmits its identifier to a server, which associates that information with stored data and then communicates back to the reader some command (e.g., an authorization). In some RFID systems, RFID servers may be tied into enterprise management platforms.



Exhibit 6-27 illustrates RFID system architecture.

Exhibit 6-27: RFID Systems



Source: Eric Teicholz, editor. *Facility Management Technology*.
Houston, Texas: IFMA Foundation, 2012.

Tags

RFID tags are plastic cases that include microprocessors, antennas, and/or power sources (usually batteries). They are classified as active, passive and semi-passive according to their configuration:

- Active tags contain a microprocessor (microchip) and a power source, such as a small battery. The power source is used to transmit a signal to a reader.
- Passive tags contain only a microchip. They are activated when the electromagnetic waves from a reader induce a current in the tag's antenna.
- Semi-passive tags have batteries, but they are used only to power the microchip. Like passive tags, they indicate their presence by drawing on the reader's signal.

Tags can be read-only (using factory input data) or may be blanks that can be programmed by the user—in some cases, by the reader device. Some tags have sensor capabilities and enough memory to store information about environmental conditions. For example, an RFID tag on a shipment of therapeutic drugs might be programmed to store evidence that the drugs have been exposed to conditions that will diminish their efficacy, such as temperature extremes or light.



Readers

Readers are described as “dumb” or “intelligent.” A dumb reader is limited in the types of tags it can read—usually only one type of tag, with one frequency and one protocol. It has little processing power besides the ability to read the tag. Intelligent readers can run multiple protocols and can actually communicate with the chips on the tags and process and store information. Readers can be stationary or handheld.

Software applications

Applications can collect, filter, and store data read from the tag. Filtering is useful since an object may be read many times if it is moving through a process. The software can filter the data to reduce data storage and processing requirements.

RFID systems and products are differentiated by tag robustness (e.g., longer lifespan, longer battery life, reusability), read range (maximum distance from a reader), the processing capacity included in tags, and their software’s ability to be integrated into other systems, such as GIS, IWMS and enterprise resource management (ERM).

Uses of RFID in FM

RFID technology has been in use for some time. Readers at toll plazas pick up signals from cars enrolled in an automated toll collection programs; charges are debited automatically from designated accounts. Companion animals are injected with sub-dermal chips so that they can be identified if lost or stolen. Production animals carry tags that can identify the animal but can also allow systems to control automatically access to feeders and update treatment records. Valuable cargo containers carry RFID to track them through the supply chain process, on and off ships, railcars and trucks, and through yards and depots.

Recognition of its usefulness in FM is expanding.

Asset management

By placing tags on objects—usually higher-value assets because of the higher system costs—facility managers can provide greater accountability for facility property.

- RFID tags can replace bar codes in inventory systems for movable equipment and furniture, tying into asset databases. Areas can be read periodically for audits to identify missing property. Assets that have been moved can be relocated through the database.
- Systems can deter theft of high value and portable assets. Readers can be placed at exits to identify when a tagged item is being removed from the premises.



Guest services

Facility visitors can be issued RFID tags programmed to provide different levels of access (e.g., allowing building access and access to certain floors or rooms). The tag can help locate a visitor quickly or track use of facility resources. For example, an RFID reader at a hot desk can log in a visiting remote worker, activating appropriate services (e.g., access to telephones or copiers) and also letting the IWMS know that the reserved room is in use.

Security

RFID is used in electronic locking systems. In some facilities, where security needs are high and occupants are not guaranteed conventional privacy rights, RFID badges can be used to track an occupant's movements in real time.

Bar codes vs. RFID

Both systems offer the same basic advantages over manual tracking: greater speed and accuracy. Each has its own advantages and disadvantages, however.

- **Robustness.** Tags are generally more robust than bar codes. While tags are encased in plastic (or under the skin of animate objects) for protection, bar codes can be scratched or worn, which decreases their readability.
- **Readability.** Bar code readers require direct line of sight, which slows the read rate considerably and limits the range as well—to less than fifteen feet. RFID readers are receiving active or passive signals that have a range of up to 300 feet.
- **Programmability.** Bar codes cannot be reprogrammed. They are what they are. RFID readers can reprogram tags.
- **Economy.** Bar codes cost about USD 0.005 (half a penny), while the cheapest passive tags may cost USD 0.03. One must factor into this, however, the productivity advantages of faster read rates. Still, if a facility has no automated asset management process in place, bar coding can be a low-cost, entry-level way to address that gap.



Progress Check Questions

Directions: Read each question and respond in the space provided. Answers and page references follow the questions.

1. Which of the following statements about BIM is correct? (*Choose one.*)
 - ☐ a. The usefulness of BIM in facility management is restricted the planning and design phase of a new building project.
 - ☐ b. BIM can model both three-dimensional space and time.
 - ☐ c. Most CAD applications include BIM functionality.
 - ☐ d. Most of the useful information in a BIM model derives from the representation of the three-dimensional image.

2. What is the best definition of clash detection? (*Choose one.*)
 - ☐ a. Identification of structural conflicts between structural components and building systems
 - ☐ b. Identification of errors in scheduling activities in a project's phases
 - ☐ c. Identification of conflicts between actions taken by various participants in a construction project
 - ☐ d. Identification of potential building code violations

3. A project manager is trying to accommodate occupant desires with the realities of a construction budget and schedule. How could BIM help in this situation?

4. List at least three ways in which BIM could be useful to facility managers in operating a building.

5. Which of the following is an imaging technology used to identify anomalies in facility electrical systems? (*Choose one.*)
 - ☐ a. BIM
 - ☐ b. Laser scan
 - ☐ c. Thermal scan
 - ☐ d. GIS



6. List at least three uses for 3D imaging in FM.

7. Which of the following would be considered attribute data in a GIS? (*Choose one.*)

- ☐ a. Compass orientation
☐ b. Bit map image of a location
☐ c. Length of a pipe run
☐ d. Type of surfacing used

8. A facility manager is trying to create a work schedule for facility technicians that will minimize travel time. How can GIS help? (*Choose one.*)

- ☐ a. By providing technicians online directions to work sites.
☐ b. By allowing technicians to visualize a future work area.
☐ c. By plotting work locations and travel time between jobs.
☐ d. By automating distribution of assignments and task completion reports.

9. Which of the following statements about RFID systems is correct? (*Choose one.*)

- ☐ a. RFID systems are appropriate only for tracking items of high value.
☐ b. RFID tags tend to be more robust than bar codes.
☐ c. Readers must have a clear line of sight.
☐ d. All intelligence resides in the server where the application is stored.

10. A visitor is issued an RFID badge that is programmed with levels of access. What other functionality could the system provide? (*Choose one.*)

- ☐ a. Rapid location of the visitor within the facility
☐ b. Access to the facility's wireless system
☐ c. Visual image of the visitor at any point in time
☐ d. Request by the visitor for assistance

11. An occupant notices a plumbing leak in a lavatory but cannot locate a custodian to report it. The occupant leaves and does not report the problem, hoping that a custodian will note the problem the next time the area is cleaned. How could a 2D code be helpful in this situation?



Progress check answers

1. b. BIM includes data related both to the 3D object/structure and changes over time. BIM can be useful in operations as well as construction. A significant amount of information other than dimensional data can be included in parametric models that add attributes to 3D data. BIM is not a capability of CAD. Rather, BIM is a methodology that employs CAD and other information systems. (p. 6-66)
2. a. Clash detection is the identification during the design phase of possible collisions between structural elements (e.g., solid wall) and building system components (e.g., duct). (p. 6-67)
3. Through rapid quantification, BIM can project the effects on budgets and schedules of different design scenarios. (p. 6-69)
4. BIM could assist in facility operations by:
 - Populating facility databases with data from the construction phase of a project.
 - Visualizing internal spaces to identify sources of problems.
 - Integrating real-time data from sensors in analytics.
 - Determining life-cycle costs of various equipment or building envelope improvements. (p. 6-70)
5. c. A thermal scan can detect anomalies, such as overheating circuits, by registering areas of increased heat in the scanned image. (p. 6-74)
6. 3D imaging can be used in FM to:
 - Document existing structures.
 - Measure space/volume of facility areas.
 - Visualize hard to access areas.
 - Create accurate “as-builts.”
 - Plan facility alterations/additions.
 - Audit contractor work. (p. 6-73)
7. d. Surfacing type would be considered attribute data in a GIS; a and c are vector data, and b is raster data. (p. 6-75)
8. c. GIS can plot work locations on a facility map and travel time between the points. This can help in grouping and sequencing calls for the most productive use of technician time. (p. 6-77)
9. b. RFID tags are more robust than bar codes, which are subject to abrasion. RFID systems do not require line of sight for readers, and readers and tags can have some degree of intelligence. Systems have different price points, depending on the capabilities of their components, and could be used to track less valuable items. (p. 6-86)
10. a. The RFID system will allow the visitor to be located in real time on a facility map. It could create a history of movements within the facility by combining data from different readers. (p. 6-86)
11. If equipped with a smartphone (and this is increasingly common), the occupant could take a picture of the 2D code and be directed via the Web to a specific area of the facility maintenance Web site. The problem and the location could be logged automatically and added, via integration with a CMMS, to the task list for maintenance technicians. (p. 6-82)



Chapter 4: Communication Technology

After completing this chapter, students will be able to:

- Describe the major changes in facility communication technology, including the confluence of voice and data communication and the impact of wireless technology and sustainable computing.
 - List organizational needs a facility manager should consider in adopting a facility communication network.
 - List advantages and obstacles to implementing wireless networks.
-

✦ Topic 1: Facility Voice and Data Communication

Evolution of facility communication technology

The ways in which the facility manager can support the organization's communication needs have changed considerably. The major forces of change have been:

- The integration of separate voice, video and data networks into one communication network
- Improvement of bit rates and capacities
- Standardization of protocols for network communication over the Internet
- Wireless technology

In addition, communication systems are being integrated with an organization's ERP and IT systems. For example, incoming calls are automatically associated with customer files in customer relationship management (CRM) systems. Some conversations may be recorded digitally and saved for compliance reasons. Incoming calls for occupants using "softphones" go straight to the facility's computer network, enabling occupants to take one phone number with them wherever they may be in the facility. FM may have to work with IT to support this integration.

The task of managing the facility's voice and data communication infrastructure has changed with technological advances and communication trends. Exhibit 6-28 overviews the major stages that communication technology has evolved through. Facility managers may be involved in technology at all different stages in this evolution.



Exhibit 6-28: Evolution of Communication Technology

Phase 1: Twisted Pair and Modems	
Telecommunication began as the transmission of analog signals over a twisted pair of copper wires—plain old telephone service or POTS. Each node in was connected via a central switching office with the public network. There were few features. Digital data was communicated from phone to phone, after being modulated from digital into analog and back again at the other end.	Business systems could include key systems that managed multiple users and offered some functionality. Some of these systems are still in use. Succeeding generations were electronic, but had the disadvantage of needing a power source. Another option was a private branch exchange (PBX) which could manage voice, fax and modem lines automatically. The PBX could support several voice features, such as hold or transfer. Businesses that needed to transmit data could construct wide area networks (WANs) to access remote computers or computer networks, using leased or switched lines, and local area networks (LANs), using coaxial cable and a networking technology, such as Ethernet.
Phase 2: Integrated Services Digital Network (ISDN)	
Voice devices began transmitting digital signals, and telephony and computing began to come together. ISDN allowed simultaneous voice and data communication within the same bandwidth, but at first the bandwidth was still limited. Data could be communicated more quickly over the Internet. Long lines were being replaced by coaxial cable and fiber optic cable, which offered higher capacity and rates. As the Internet expanded and a standard communication protocol developed (TCP/IP), data communication began to occur over the Internet through Internet service providers.	ISDN's data rate was not significantly greater than POTS. Some facilities installed lines that could carry more traffic and at higher rates. A T1 line can carry 1.5 Mbits/second. Intranets were developed within facilities, using IP technology to create a private version of the public Internet over the facility communication network. Occupants could share information on networked servers, according to security level.
Phase 3: Broadband	
With more bandwidth, users envisioned the possibility of combining voice, data and compressed video over the same lines. This would take much higher transmission rates than that available with standard telephone service. Later, digital subscriber line (DSL) ISDNs offered access to the Internet at higher speeds on specially conditioned lines.	Video phones and video conferencing were the goals. Equipment was expensive and cumbersome, but did come down in price and size. Some organizations created video conferencing centers, some of which relied on satellite technology rather than wired communication networks.
Phase 4: Internet and Wireless Technology	
ISDN has been eclipsed by the Internet, which is increasingly being used to transmit voice as well as data and to stream audio and video. Long-distance calls made over the Internet are less expensive. Web camera-enabled computers make video calling simple and inexpensive. Wireless technology has enabled the latest generation of mobile devices to combine voice with data (including video) streaming.	The distinction between facility voice and data communication systems has become irrelevant. To save money and decrease their carbon footprints, many organizations embrace distance communication and implement it over the Internet. Wireless technology helps facilities lower wiring costs, increase the flexibility of facility space and accommodate the new mobile occupant.



Key terms

Exhibit 6-29 includes some key terms related to integrated communication technology (ICT).

Exhibit 6-29: ICT Terminology (continued on next page)

Term	Definition
3G/4G	Third generation and fourth generation mobile communication system. Generic name for mobile network/service based on the International Mobile Telecommunications (IMT) family of global standards.
Bandwidth	The range of signal frequencies that can be carried on a communications channel. The capacity of a channel is measured in cycles per second, or 1-hertz (Hz), between the highest and lowest frequencies. While this indicates the channel's information-bearing capacity, it is more commonly expressed as "bits per second."
Digital subscriber line (DSL)	One of a range of technologies which allows high-bandwidth services to be carried over a traditional copper twisted pair. The bandwidth achievable usually depends on the length of the copper pair.
General packet radio service (GPRS)	A standard for wireless communications which runs at speeds up to 115 kilobits per second. GPRS is an integrated part of the Groupe Specific Mobile (GSM) standard.
Groupe Specific Mobile (GSM)	European-developed digital mobile cellular standard.
Integrated Services Digital Network (ISDN)	A digital switched network supporting transmission of voice, data and images over conventional telephone lines.
Internet	A global system of interconnected computer networks that use the standard Internet protocol suite.
Intranet	An electronic communications network, based on the same overall design as the Internet, but used for communications among the departments and locations within one organization.
Local area network (LAN)	A computer network contained within a relatively small area. May also be connected over any distance via phone lines, fiber optic cable, satellite, and radio waves.
Private branch exchange (PBX)	A larger and more feature-rich telephone system that is part of the broad category of customer premises equipment, which refers to equipment owned, installed, and maintained by the customer as opposed to the service provider.
Transmission Control Protocol/Internet Protocol (TCP/IP)	A suite of communications protocols used to connect hosts on the Internet.
Virtual private network (VPN)	A network that provides virtual circuits and that is established by using the facilities of a real network; a private network, usually encrypted, that is configured within a public network, such as the Internet. VPNs are inexpensive ways to create WANs.
Voice over Internet Protocol (VoIP)	The standard that the Internet uses to allow computers to communicate. It transmits both voice and data traffic.



Exhibit 6-29: ICT Terminology (concluded)

Term	Definition
Wide area network (WAN)	Two or more local area networks (LANs) that span a relatively large geographical area. Global enterprises can lower costs by linking facilities through a WAN. The Internet is a type of WAN.
Wireless access point	A device that allows wireless communication devices to connect to a wireless network. The wireless access point usually connects to a wired network, and can relay data between the wireless devices (such as computers or printers) and wired devices on the network. Referred to popularly as a Wi-Fi™ hotspot.
Wireless local area network (WLAN)	Local area networks that use radio frequency transmission technology to transit information from one point to another. Referred to popularly as Wi-Fi™, for the first widely used wireless technology, standard 802.11b, and its subsequent versions.

✦ Topic 2: Managing ICT Systems

Facility manager challenges

In an existing building, most facility managers are faced with communications systems that have grown in an unplanned fashion that does not allow the facility to take advantage of new technology. There is probably too much cabling and wiring, since the safest choice is always to include more capacity than is actually needed. As mobile communication and VoIP increase in use, the need for this infrastructure decreases.

Newer structures and furnishings have been designed for flexible use of space, but older workplaces often have wiring plans or furniture that make moves and repurposing of spaces difficult and expensive. Implementing open space design when all the cabling is in walls or ceilings is a practical and aesthetic challenge. Accommodating inflexible furniture configurations may require installing new cabling.

In addition, FM must plan for the physical needs of new technology:

- The additional space required for LAN rooms and server rooms
- Infrastructure components to support those spaces, such as additional cooling and ventilation, additional storage, specialized cabling
- Business continuity issues, such as backup generators and uninterruptible power supplies (UPS) or even a full backup system in a remote location for disaster recovery

Facility managers must seize opportunities to rethink facility communication structure and make it more rational, aligning it with the organization's



Assessing facility communica- tion needs

communication needs and reducing its costs. Even if changes must be made in a piecemeal fashion, each change can be leading the facility toward a more functional communication plan.

A simple needs assessment can help a facility manager create a more productive alignment of facility communication technology with organizational processes and practices. Through interviews with function heads and site visits to workplaces, facility managers must:

- Understand how occupants use the communication network. This includes questions such as:
 - Whom do occupants communicate with internally? Do they need to share data with these individuals? Do they need access to shared databases?
 - Whom do occupants communicate with externally? Do they make long-distance or global calls?
 - Could video-enabled communication technology, such as Web conferencing, improve team or customer communication and reduce travel?
 - What type of files do they share internally or externally? What quality and speeds do they require?
- Determine the level of mobility in the workforce and how that affects communication.
 - Do many occupants work remotely?
 - Do many occupants prefer to communicate and be reached through mobile devices?
- Gather data about the organization's use of space.
 - Is the organization seeking to reduce its footprint by increasing the number of small satellite offices or having employees work from home?
 - Is the organization moving away from fixed work stations or offices to temporary team areas?
 - What is the organization's churn rate? How is it trending?
 - What is the average cost of an internal move?
 - What are IT's space and connectivity needs and priorities (e.g., location of closets and data rooms)?
- Identify special needs, such as:
 - Enhanced security on all external communication.
 - Low tolerance for interruption of service and increased need for backup systems and planning for continuity in the event of a disaster.



- Compliance issues (e.g., call logging).
- Occupants with disabilities who require adaptive technology.

A facility manager will rely on the advice of an expert communication system designer, but the result will be only as sound as the information input into the process.

✦ Topic 3: Optimizing Facility Communication Technology

Advanced strategies

Taking advantage of the latest communication technology will enhance a building's value and support occupant and organizational productivity. Communication technology upgrades can be an opportunity to integrate building controls with the communication system. For example, security systems can be integrated with communications networks, using existing cabling to carry camera images or issuing alerts to occupants. Energy management systems could use wireless networks to power down devices.

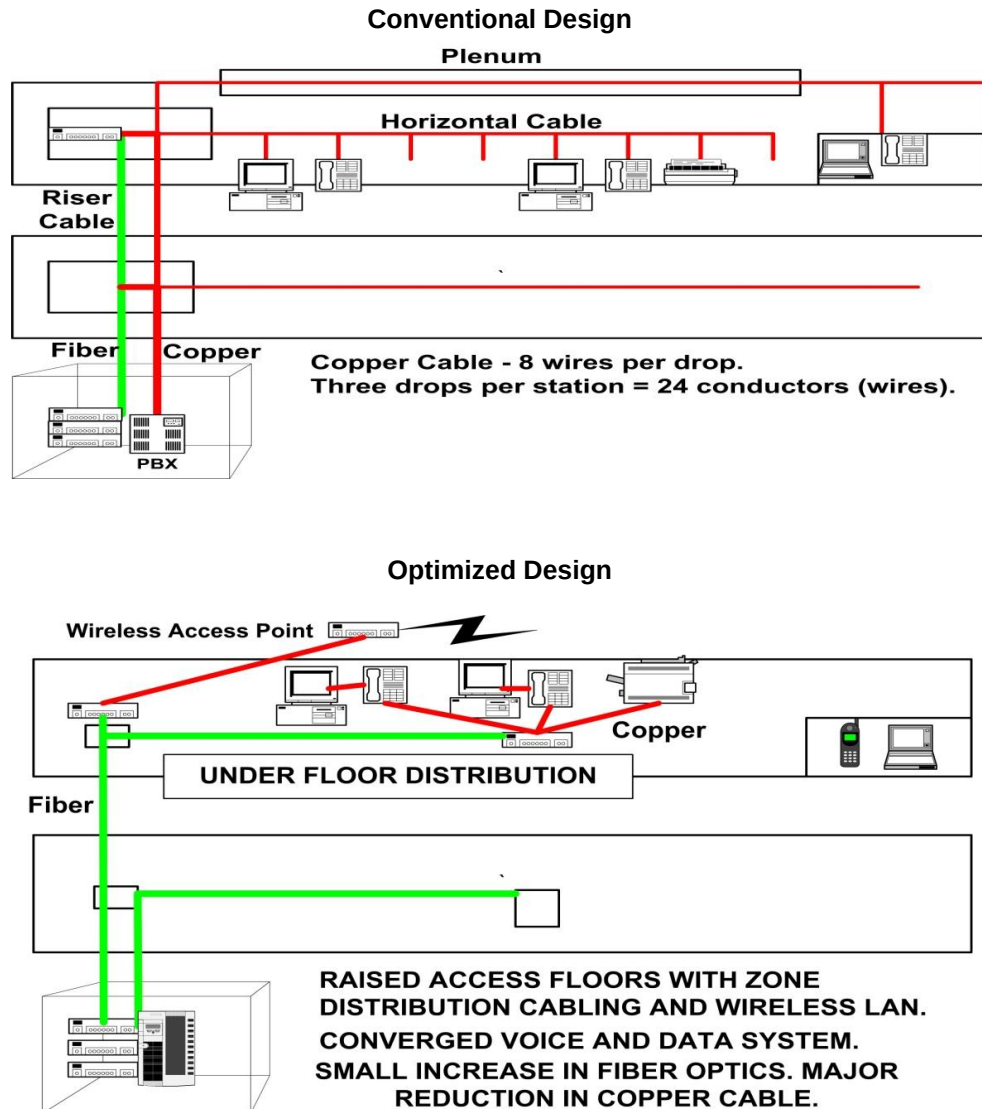
However, these projects require collaboration and regular communication with IT. The IT function can bring to the table technical expertise in building networks and integrating systems, but the facility manager brings thorough awareness of the physical attributes of a building and how structures can enable or limit implementation.

In *Facility Management Technology*, Richard Hodges contrasts conventional approaches to wiring for voice and data with an alternative design that is more flexible, economical and sustainable. Exhibit 6-30 on the next page shows these two approaches.

In a conventional approach, because of limitations on the lengths of copper runs and the need to tie data lines into routers, separate data cables and copper voice wiring—and perhaps coaxial cables for audiovisual transmission—are homerun on each floor of a multifloor facility to an intermediate distribution frame. These frames are typically located in wiring closets on each floor. The intermediate frames are stacked vertically above a main distribution frame. Wiring and cabling are run through the plenum, dropping at regular intervals (usually inside walls or permanent furniture) to fixed connection points. The wiring is expensive and the connections difficult to alter. Wiring closets take up room that could be used more productively.



Exhibit 6-30: Contrasting Approaches to Communication Network Design



Source: Eric Teicholz, editor. *Facility Management Technology*.
Houston, Texas: IFMA Foundation, 2012.

An optimized design converges voice, data and video into a single fiber optic vertical feed to each floor. The optimized design has several advantages:

- Rather than locating all connections in a single closet, the design calls for a modular network organized into zones, with network components (e.g., Ethernet switches, power supplies, wireless access points) located under raised floors. Modules can be added or moved according to occupant needs. This replaces fixed and excessive wiring for drops to possibly nonexistent workstations with copper wiring from the zone to equipment actually in use.

- Ceiling-mounted wireless access points can also be copper wired into a network component to improve reception or provide service for hard-to-wire spots.
- The space required for closets is greatly reduced, making space use more flexible and productive. Since the trend has been for these closets to become larger and larger, with the addition of LANs and VoIP, an opportunity to control closet size is appealing.
- Fiber optic has greater capacity than conventional cabling and wiring (fiber optic can even support distribution of video over IP), is less susceptible to the effects of electromagnetic fields created by facility equipment, decreases the building's fire protection load and fire suppression systems, and is more sustainable since it uses less material resources to produce an equivalent amount of transport capacity and uses less energy.

Did You Know?

According to a European study, fiber optic cable could reduce energy consumption by 34 watts per 10 Gigabit link (combining 24 watts in reduced power consumption plus 10 watts in reduced need for cooling). In addition, fiber optic is less environmentally disruptive. Copper extraction processes require about 500 kilograms of environment (e.g., excavated ground, water) to produce 1 kilogram of copper. To produce one kilogram of fiber optic requires only 3 kilograms of environmental resources. To depict that in finished product, 24 ten-gigabit copper links require 33 kilograms of copper, while the same number of links and the same link lengths requires only 56 grams of glass. One must remember as well that less material means less waste for future disposal.

Implementing wireless networks

New “smart” buildings incorporate wireless local area networks (WLANs)—popularly referred to as Wi-Fi—into their overall communication strategies. This trend has been driven by a number of factors, including the combination of data and voice communication, the adoption of smartphone technology, the importance of enterprise data and processes and increasingly mobile work habits. In addition, wireless networks are relatively low cost and easy to install and use a common standard protocol.

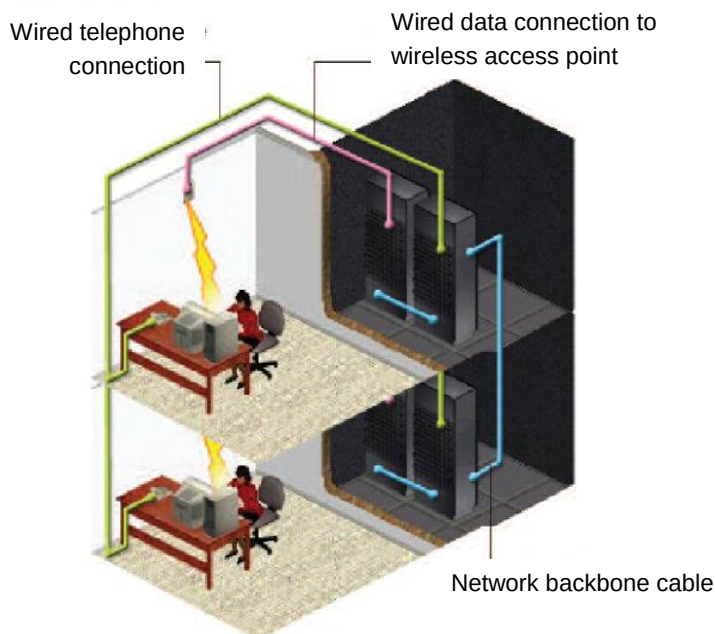
Many wireless networks may be part of a hybrid communication system—providing service to certain parts of the facility while the other parts are served by a cabled network. Facilities may choose to implement Wi-Fi hot spots in



areas where the potential for use is high, such as in meeting rooms or cafeterias or lobbies. Wi-Fi hot spots may also be an alternative for buildings in which implementation of facilitywide wireless networks would be difficult.

In some implementations, wireless zones with ceiling-mounted access points operate in a parallel manner alongside conventional cabled networks. This enables occupants to use mobile devices as their primary work tools, which may make sense in an organization with a high proportion of remote workers who use the facility sporadically or visitors who will need connectivity during their stay. Exhibit 6-31 shows a wireless installation in which wireless entirely replaces cabled data.

Exhibit 6-31: Wireless Data Communication Installation



Source: Steve Falkin and William Sellers. *Wireless Systems in the Facility*. Houston, Texas: IFMA Foundation, 2005

System design factors include the types of communication that occur and the number of users. Type of use affects the size of bandwidth specified in the network, while the number of users affects the number of access points that may be needed. As users increase in number, so do access points.

Access points can be mounted on ceilings, walls or desks, depending on the coverage area. They can be installed in plenums, if local codes allow. Access points must be powered. This can be either through wiring or by using a

system that couples power supply with Ethernet cables (power over Ethernet or POE). The system may also require installation of wireless cards in computing devices, which will involve facility management with IT.

Benefits of wireless networks

While wireless networks do not presently have the same bandwidth as wired networks and reliability may be lower, wireless has many offsetting benefits, including:

- Integration with core building systems for increased energy efficiency and security.
- Integration of smartphones into work processes. For FM, this means that technicians can receive work orders and respond and access online information (e.g., parts catalogs and ordering, manuals, technical support) in real time. Smartphones are increasingly becoming an important tool to increase staff productivity.
- Enhanced value and appeal to tenants.
- Decreased use of cabling and as a result decreased cost (both materials and installation) and building fire protection load. In general, a fully wireless network requires 40 percent of the cabling in a wired system.
- Networking of hard-to-reach areas. This includes not only providing communication service to occupants but also networking building system elements that would not be feasible to wire into a BAS. In historic buildings, where interiors cannot be disturbed, wireless may be the only option. Some leases may also restrict wiring installations to limit damage to walls.
- Faster setup and connection of new occupants to communications.
- Enhanced productivity since occupants can access and share information wherever they are—especially with the increasing use of smartphones and tablets.

Challenges of wireless networks

Despite their benefits, wireless networks have their own challenges, and these challenges make collaboration with IT and system experts advisable.

- **Facility factors.** Certain building characteristics, such as foil-lined ceilings, may inhibit wireless transmissions. Interference from building materials (e.g., concrete and steel) and radio frequency interference from devices can diminish network speed. Facility layout can create areas with weaker reception. Some of these issues can be overcome, but expert advice will be needed to develop solutions that are both reliable and cost-effective.



- **Use factors.** As suggested earlier, the system must be designed to support the anticipated traffic, but inevitably traffic will occasionally exceed the anticipated range, and users will experience slow transmission rates or will not be able to access the network. Users trying to upload or download very large files may not be satisfied with wireless transmission speeds.
- **Occupant safety.** Weak or failed reception during an emergency is not acceptable. Facilities that rely on wireless networks should consider this when planning emergency communication and test alternative methods of communicating with occupants.
- **Security.** Security of wireless communication is a primary concern for organizations. The U.S. Department of Homeland Security recommends several steps to securing wireless networks:
 - Changing default passwords on access point devices
 - Restricting access to authorized users. Multiple wireless networks with different levels of security can be created to accommodate visitors.
 - Encrypting data
 - Installing not only a network firewall but a host-based firewall on wireless devices



Progress Check Questions

Directions: Read each question and respond in the space provided. Answers and page references follow the questions.

1. List the four major developments in communication technology that have most strongly affected facility communication technology.

2. Which of the following statements about the evolution of workplace communication technology is correct? (*Choose one.*)

- ☐ a. Voice and data communication systems have grown increasingly distinct.
- ☐ b. Speed of transmission has increased, but not quality.
- ☐ c. Broadband connectivity has been eclipsed by Internet access.
- ☐ d. VPNs have been replaced by Internet connectivity.

Link the communications technology terms on the left with the correct description on the right.

- | | |
|--------------------|--|
| 3. _____ Bandwidth | a. Private network within a public network |
| 4. _____ Intranet | b. Voice and video communication over the Internet |
| 5. _____ VPN | c. Factor related to data transfer speed |
| 6. _____ VoIP | d. Private network composed of multiple LANs |
| 7. _____ WAN | e. Network of users over large area |

8. Why should a facility manager ask about the locations occupants call most often?

9. Which of the following statements about fiber optic cable is correct? (*Choose one.*)

- ☐ a. Fiber optic cable as less capacity but better quality than coaxial cable.
- ☐ b. It is best used in short runs.
- ☐ c. It cannot be used in areas where the potential is high for interference from electromagnetic fields created by facility equipment.
- ☐ d. It has fewer environmental effects than copper wiring or cable.



10. Why does the number of users on a wireless facility system make a difference? (*Choose one.*)

- ☐ a. A large number of users reduces security.
- ☐ b. Access to and quality of service can be limited by the number of users.
- ☐ c. Access points operate most efficiently when the number of users is close to its maximum capacity.
- ☐ d. A larger number of users can help decrease system costs.

11. The owners of an office building are reluctant to invest in a wireless system for its tenants. List at least two benefits the facility manager could offer to support the investment.



Progress check answers

1. The four key developments in voice and data communication have been:
 - Integration of voice, data and video networks
 - Improvement of bit rates and capacities
 - Internet protocol standardization that enabled VoIP
 - Wireless technology (p. 6-90)
2. c. Broadband connectivity has been eclipsed by Internet access. Networks have become more integrated, rather than less. Both transmission rate and quality have improved. VPNs have not been replaced by the Internet, but are facilitated over the Internet. (p. 6-91)
3. c (p. 6-92)
4. d (p. 6-92)
5. b (p. 6-92)
6. a (p. 6-92)
7. e (p. 6-93)
8. If occupants frequently call globally, it may be more cost effective for the facility and IT to implement VoIP for occupants. An additional benefit would be the possibility of simultaneous video and voice communication, which could support productivity. (p. 6-94)
9. d. Fiber optic places fewer burdens on the environment than wiring alternatives, and offers at least as good performance. (p. 6-97)
10. b. The higher the number of users on a particular access point, the greater the chance users will experience lower quality of service. Adding another access point would solve the problem, but it would increase, not decrease, system costs. (p. 6-98)
11. Implementing a wireless system in the building could:
 - Satisfy needs of tenants who rely on mobility within the facility.
 - Increase the asset's value.
 - Attract tenants. (p. 6- 99)



Chapter 5: Workplace Technology

After completing this chapter, students will be able to:

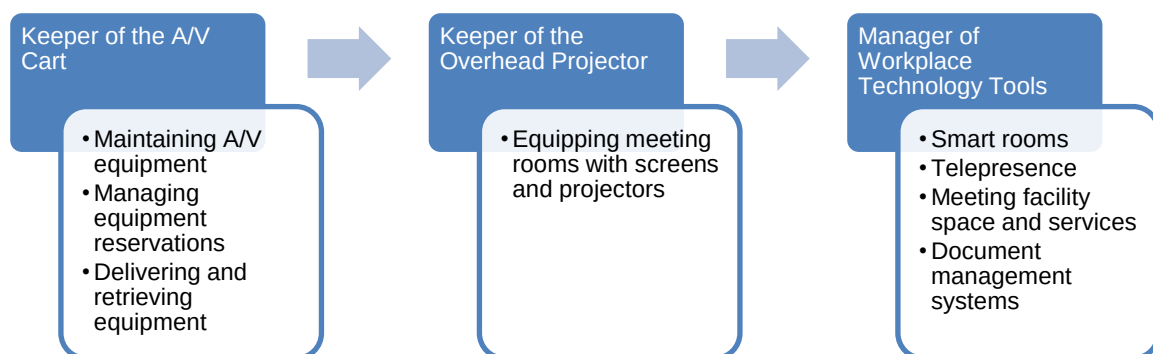
- Describe facility management strategies for using new technology to support:
 - Occupant creativity and collaboration
 - Workplace mobility
-

✦ Topic 1: Supporting Workplace Innovation

In the last half of the 20th century, the term *business incubator* was coined to describe programs that promoted companies engaged in entrepreneurial activity—the kinds of businesses that would stimulate economic growth through new jobs and products and advance the economy through the development of new technology. In a much less conceptual way, facilities are business incubators as well. They provide a place that can stimulate creativity and innovation and clear away some mundane obstacles to productivity.

Just as the task of operating building systems has changed over time and in pace with technology, the role facility management plays in creating a workplace that fosters productivity, collaboration and creativity has also evolved. As Exhibit 6-32 shows, facility management may have started by providing equipment, but it now participates with management and occupants to find and implement tools that will help the organization achieve its strategic goals.

Exhibit 6-32: FM and Workplace Technology



Facility managers were expected to acquire, maintain and distribute meeting or presentation equipment—at first, film and slide projectors and later transparency equipment and VCRs and monitors. The goals were sufficiency, reasonable availability, and reliability. Sufficiency is no longer enough. Today's facility manager is expected to provide rooms already equipped with state-of-the-art equipment that produce quality visuals and audio, telepresence for video conferences and seamless integration of data from multiple sources.

The task of the facility manager now is to blend space and technology with seeming effortlessness so that occupants can focus on the work at hand, rather than on the distractions of the room they are in, how far apart the participants may be and how clumsy the meeting tools may seem.

Technology and effective space

Although this competency focuses on technology, it may be helpful to remember that good use of space is not driven by technology but by environments that support interaction and creative thought. Supporting the effective use of space involves allocating space to meet both team and individual work, formal and informal meetings, and different team styles.

What does this mean to facility managers?

- First, meeting spaces must be varied in size and levels of technology.
- Second, rooms must be equipped with technology appropriate to the space's purpose. Technology should support rather than encumber thought. A café may need only wireless connectivity, while a formal meeting room may need merged video, audio and data applications. A global project team may require telepresence so that participants feel they are in the same place, while a small, development team working face to face may need connectivity to data and applications and the ability to project, discuss and revise ideas as they work.
- Third, the room should physically support the technology being deployed there. Colors should be chosen with video in mind. Outside light and glare must be controlled. Furnishings should contribute to comfort and the ability to work, but also to better acoustics, softening room sound and insulating the room from external sounds. They should also be easy to arrange.
- Fourth, meetings spaces must be equitably managed. IWMS applications can be used to reserve meeting space on a first-come/first-served or team-priority basis. Occupancy sensors can indicate when a space is available again, so that the reservation system can update its availability. In addition to providing greater transparency about the use of facility space, these systems can manage chargebacks for space use—and for using the room beyond the reserved time or for failing to cancel or canceling too late. They can also capture and store data for analysis of space utilization.



- Fifth, facility managers must remember to accommodate solo work needs as well as team needs. Occupants' workplace needs are discussed in more detail in the *Human Factors* competency.

The general challenge of creating workspaces appropriate for a mobile workforce is discussed further in the *Human Factors* competency.

Workplace technology

Just as buildings are becoming “intelligent,” rooms are becoming “smart.” Smart meeting rooms today minimally include:

- Voice, video and data connectivity so that meeting participants can easily access and share information. This may include wireless connectivity.
- Video, audio and data conferencing capabilities.
- Digital projection systems.
- High-quality monitors that offer large but clear areas that can be viewed from different angles.
- Efficient equipment placement and storage.
- Means to record and interact with team work. This may involve:
 - Copy boards that send anything written on the board to a printer.
 - Interactive whiteboards that are directly connected to computers. Participants can project content from their computers, move and group content, and save the marked up, revised content.
 - Room recording systems.
- Room control systems to manage the various technologies, sound and light levels and window shades from one location.

Smart rooms can be built or implemented as turn-key operations from IT manufacturers. The turn-key solution may help facility managers handle the physical challenges of high-tech rooms—specifically, ensuring ample and flexible power and data connections that avoid awkward wiring arrangements that can trip participants.

✦ Topic 2: Supporting Workplace Mobility

Chapter 1 described the current trend toward a more mobile workforce, and the issue of accommodating mobility has recurred in discussions of communications technology and space management. Perhaps one of the best ways for facility managers to understand a mobile worker's needs is to put themselves in the worker's place. The following case represents a hypothetical experience in an organization that has adopted mobile work patterns.



The Challenge of a Mobile Workforce

Imagine that you work primarily from home and on the road. Your home office is about three hours away, and you spend at least three days a week traveling to client facilities and working there. You come into headquarters about once a month. Your office is your laptop, your tablet and your smartphone. And you need that smartphone. It has GPS, your contacts list, your schedule. You probably receive a hundred calls, voice messages and texts from clients each day. You also use it to follow several industry Twitter users and you yourself send weekly tweets to clients about items of interest. But you also need that tablet. It makes e-mail and data retrieval simpler. You have videos on it to show clients. You use it to update your blog and monitor comments about the company on the social media.

It is your day to come to the headquarters facility. After your three-hour drive, your first headquarters experience is a 15-minute drive around the campus, looking for a parking space. After a hike to your building, you need to sign in and retrieve a visitor's card. (The organization decided for security reasons not to allow remote workers to keep a permanent security card.) There's a long line and another 15 minutes lost.

Next comes the process of finding a place to work. As luck would have it, everyone is healthy, and no desks are unoccupied. You settle into a small conference room, but have to leave almost immediately to accommodate a scheduled meeting. With some help from an administrative assistant, you find an unoccupied space a couple of floors down from the people you will be meeting and working with. The room is very dusty and cluttered; the surfaces, including the telephone handset, are dirty and sticky. There are no locked drawers in which you can store your things while you may be away from the room. You settle in finally, and then discover that you have forgotten your power cord for the laptop and the recharging cord for your tablet and phone. Before your phone dies completely, you forward your calls to the phone at your desk. It is oddly quiet all morning. You find out later that all your calls have been directed to the voice mailbox of someone who no longer works with your organization.

Lunch time goes no better. You meet with a colleague with whom you try to discuss some files, but you can't get a wireless signal on the tablet.

Your afternoon meetings are a form of guerrilla warfare as you try to secure a room large enough for all the attendees and alert attendees about the location. During the meetings you are hampered somewhat by not being able to access the files you need. A paper-based contract is lost in the workflow process and currently inaccessible. There is no video projection system. Everyone must huddle around your tablet to watch a video.

Mercifully, the day ends. You wait in line to turn in your security card, sprint back to your car and head home. With luck, you will have enough gas to get there. It would have been nice to be able to recharge your hybrid during the day. You remember a comment from a co-worker earlier in the day: "It must be so nice to work from home." But you don't always. And that's the problem.



A mobile solution

FM technology and practices can make this remote worker's life considerably easier.

- An IWMS could have allowed the worker to request a security badge and appropriate office space before leaving home—and possibly a charging site for the car. Appropriate meeting rooms could have been reserved online as well.
- The worker could go to a parking page on the facility's Web site and see, in real time, where open spaces are.
- Logging into a kiosk would let the worker check in and learn where the office is located.
- All hot desks could be equipped with docking and recharging stations for the standard equipment supported by the organizations.
- Areas designated for hotelling could be included in janitorial schedules and equipped with sanitary wipes so that occupants can clean surfaces.
- Mobile workers can be provided with the means to store their possessions securely.
- Incoming calls to the worker can be automatically routed to the employee's computer via a softphone application.
- Cafeteria Wi-Fi would have made lunch more productive.
- Meeting rooms would be equipped with necessary technology.
- Paper files could have been scanned into and accessed from a document management system.

It takes more than technology to meet stakeholder needs and support organizational productivity. It takes empathy, imagination and knowledge.



Progress Check Questions

Directions: Read each question and respond in the space provided. Answers and page references follow the questions.

1. A facility manager is working with a designer to develop templates for meeting space throughout the global organization. List at least three principles the facility manager should keep in mind during this process.

2. Which of the following is true of an interactive whiteboard? (*Choose one.*)

- ☐ a. It can retrieve and display documents from a document management system.
- ☐ b. It has voice and video capabilities.
- ☐ c. It saves data entered on the board into a connected computer system.
- ☐ d. It networks users globally in smart meeting rooms.

3. An organization relies heavily on collaborative teams that work together intently, often more than 12 hours a day, for periods up to a year. Then the team members are assigned to new projects and a new team structure develops. To respond to this organizational process, facility management provides ample large, open work areas with network connectivity and projection equipment. What else could they do to support the teams? (*Choose one.*)

- ☐ a. Implement a wireless network in the facility.
- ☐ b. Implement policies to limit work hours.
- ☐ c. Provide smart rooms with videoconferencing capability.
- ☐ d. Remove voice communications from the work areas to decrease distractions.



Progress check answers

1. Meeting rooms should:
 - Accommodate groups of different sizes.
 - Be equipped with technology appropriate to the room's customary use.
 - Support technology systems in terms of décor, layout and furnishings.
 - Be equitably managed. (p. 6-105)
2. c. An interactive whiteboard in a smart meeting room is connected to a computer network that allows users to add data from the computer to the whiteboard and to save on the computer system whatever is written on the board, including changes that have been made to displayed data. (p. 6-106)
3. a. The teams could benefit from a wireless network in two ways. They could periodically move their work to other areas in the facility, such as a cafeteria or outdoor courtyard, which would create a diversion and possibly spur creativity. Second, by issuing employees wireless phones, the organization would not have to reassign phone numbers as teams are redrawn. (p. 6-106)



Chapter 6: Implementing Technology Projects

After completing this chapter, students will be able to:

- Summarize reasons why facility technology projects fail.
 - Explain the technology optimization process and its benefits.
 - Identify challenges at each stage of the project management process from the perspective of a technology project.
-

★ Topic 1: Optimizing Facility Technology Projects

Challenges in implementing new technology

Although technology usually comes packaged with the word “promising” on the outside, what comes out of the box sometimes disappoints. The complaints vary. A purchased system does not produce the time savings it promised. Integration is never fully achieved. Some functionality is never taken advantage of because users find the system too complex. Worst, a system comes on line, doesn’t work, data is lost or corrupted and the organization cannot go back to the previous system because it has been taken down and the database transferred to the new, nonfunctioning system.

Why do some technology projects go well and others, that are just as well-intentioned, go so wrong? Some of the following points are common to all projects, and students are referred to the *Project Management* competency for more information about this general process. However, successful technology projects do share some common characteristics.

- **Stakeholder buy-in is ensured.** Technology projects are usually resource-intensive. Those who will approve funding and those who will be affected by the technology must be involved at an early stage. Their support is conditional on their participation in envisioning what the proposed technology can do for them and, if necessary, prioritizing “pain points.” Stakeholders include:
 - Management, who will need to see business cases that provide the costs, advantages and risks associated with different options.
 - IT, who will want to know about the compliance of the proposed technology with corporate standards.
 - Clients (e.g., occupants, line managers, suppliers). Their support is needed as well.



- **The project is aligned with organizational needs.** Organizational need should drive change, rather than the availability of new technology. And those needs must be studied in sufficient depth to ensure that the selected technology can support all the organization's activities at the desired service level.
- **The project's requirements are realistically assessed.** Optimism may be a fine personality characteristic, but implementing a technology project requires realism, even if this means increased resistance from the organization. A realistic assessment of the process will prepare the organization for foreseen and possible costs and inconveniences. A project must be adequately funded.
- **The organization is prepared for change.** A facility manager must gauge the organization's ability to absorb the change in vision and processes that the new technology implies. As with all changes, the ground must be prepared for technological change. Management and occupants must be educated about the effects of the change and motivated by possible benefits specific to their needs. Some organizations will not be ready to make the change as envisioned by the facility manager. The process may have to be broken down into smaller steps so that the organization can gain confidence in the technology as well as expertise required to use the technology.
- **Processes are analyzed and corrected before the project.** Chapter 2 mentioned the problem of building automated systems on a platform of faulty processes. Process analysis and improvement should occur before implementing technology.
- **The project team communicates effectively.** Project leaders must define channels of communication and communication expectations. They must ensure that team members are sharing, rather than hoarding or protecting, project information. Good news must be circulated within the team and the organization. Bad news must be shared, owned and mitigated. Breakdowns in communication among team members can sabotage good technology.
- **The project schedule and budget are managed.** The designated project manager tracks milestones and budgets and communicates issues as quickly as possible with stakeholders.
- **The project is well documented.** Technology projects inevitably evolve as more is learned about the technology's capabilities and limitations and adjustments needed to meet the project's objectives. Every change must be



documented. This is useful in evaluating the project, but understanding why something was done in a certain way will also assist in maintaining and upgrading the technology.

- **The implementation strategy is well planned and executed.**

Implementation includes quality testing of data transferred or entered into the new system. The transition to the new technology must be planned. Especially if a process is critical, it is advisable to do a pilot test before cutting over. Implementation also includes training of operators and users. The fact that a process is being automated does not mean that those affected can be left uninformed. New processes must also be supported through revision of standard operating procedures (SOPs) and policies, if necessary.

- **Training needs are identified and addressed.** The needs for new knowledge and skill must be identified for each group involved in the new technology. Technicians must be trained on how to use the technology, support personnel must be educated about possible problems and solutions, and occupants should be educated about how the technology will affect them. Occupant expectations should be accurate.

- **The right metrics are chosen and used.** Every project should end with evaluation of results against objectives, but doing this requires that facility managers begin the project with specific metrics related to anticipated outcomes. These are quantifiable improvements in performance, such as:

- A specific increase in meeting room utilization
- A percentage decrease in energy bills or labor budgets
- A time frame within which information is communicated
- A specific improvement on an assessment

Technology optimization process

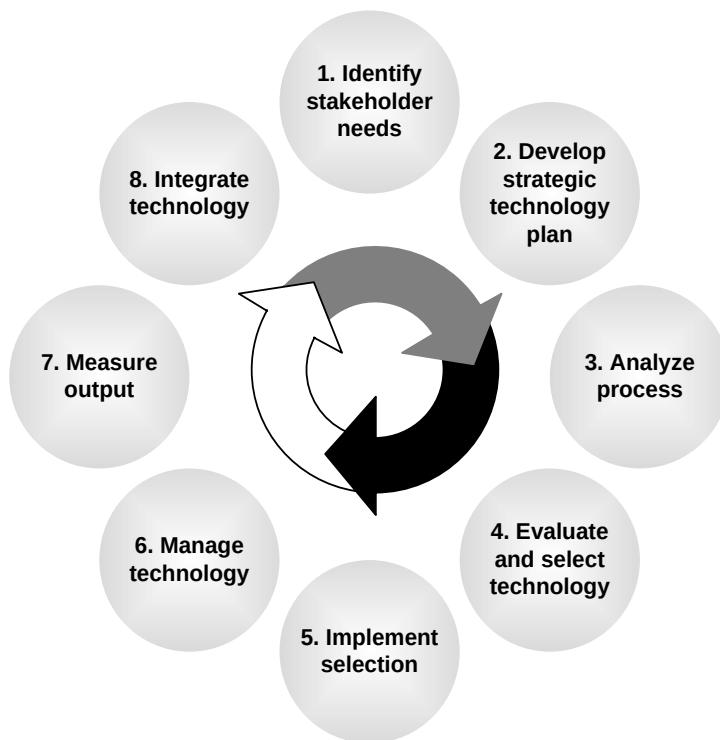
The technology optimization process, shown in Exhibit 6-33, is a way of ensuring that new facility technology is implemented smoothly and to the satisfaction of all those involved.

The model has eight steps:

1. Identify stakeholder needs: Alignment of new technology with stakeholder requirements, as discussed in Chapter 1.
2. Develop strategic technology plan: Ensuring plan is aligned with the organization's strategy and stakeholder needs, also discussed in Chapter 1.
3. Analyze process: Ensuring that the technology project is built around an effective process that will meet user requirements.



Exhibit 6-33: Technology Optimization Process



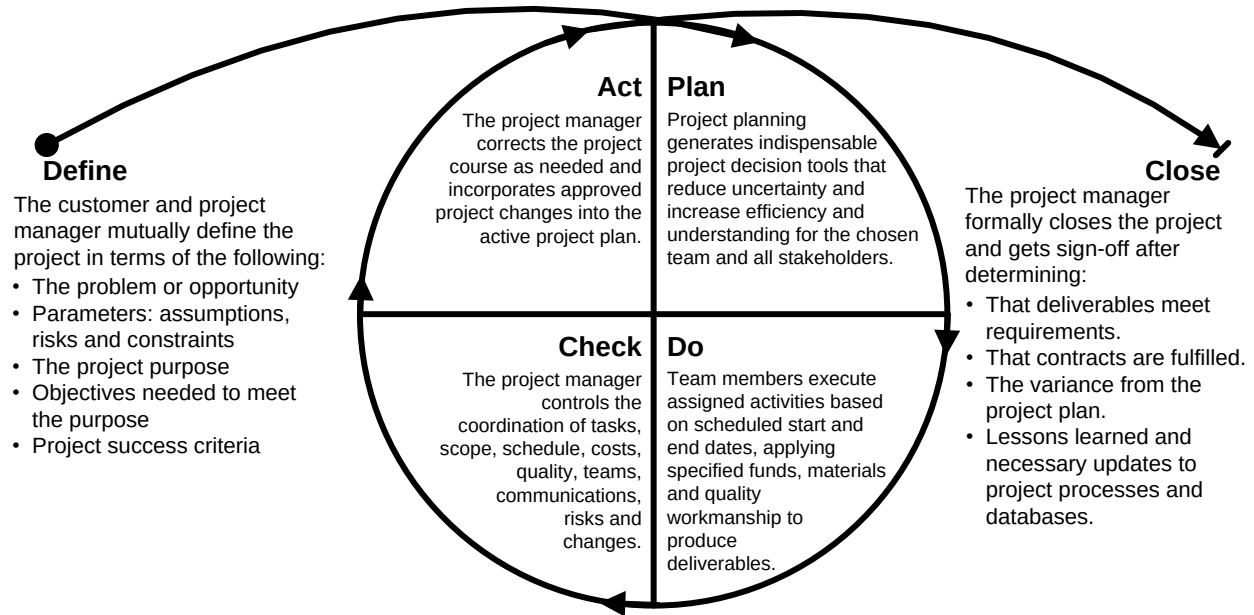
4. Evaluate and select technology: Using various analytic tools, such as SWOT (Strength/Weakness/Opportunity/Threat) analysis and cost effectiveness analysis, to support sound choices.
5. Implement selection: Managing system configuration, database population and system roll out.
6. Manage technology: Maintaining technology and documenting changes.
7. Measure output: Assessing the use of the technology to produce desired metrics in specific functions, such as space management or energy management.
8. Integrate technology: Ensuring that the technology becomes part of the organization's enterprise management system, integrating technology and enterprise databases and supporting integrated processes, such as project and asset management.

Steps 3 through 6 represent the traditional activities involved in project management. Topic 2 will focus on the types of challenges that occur in each of these steps during technology projects.

✦ Topic 2: Project Analysis and Implementation

The rest of this chapter will focus on the remaining stages in this process, which corresponds with the Plan, Do, Check, Act (PDCA) model (see Exhibit 6-34) introduced in the *Project Management* competency. Examples from actual facility experiences with new technology projects are also included.

Exhibit 6-34: Project Management Model



Plan

The planning process involves the gathering and analysis of information to determine the best solution.

Technology needs assessment

A technology needs assessment can be a useful place to start. It is a good practice to perform a general technology assessment periodically. A general assessment focuses on information such as:

- What applications are being used by facility management?
 - Have the applications been reviewed for conformity with standards by IT? Besides avoiding technical problems, IT review may also help the organization manage the acquisition of software licenses more economically. Duplicate licenses and maintenances fees can be avoided.
 - Have the applications been maintained properly?
 - Are they being used in accordance with licensing requirements?
 - Are the applications being underused, in terms of the number of licenses purchased?



- How well is each application fulfilling the function's and organization's needs? Brief interviews with users and clients can help answer this question.
- Is the application adequate to meet the organization's future plans and anticipated facility changes?

To support a particular project, facility managers may have to use questionnaires, focus groups, observation and interviews to gather information from those involved or affected by the project:

- Management, who can discuss the organization's strategy, the results of SWOT analyses and strategic priorities
- Facility management clients—occupants who can describe the desired output of the technology, their goals and limiting factors
- Users, such as technicians, who can suggest project criteria from an operational perspective

As mentioned in Chapter 2, facility managers should also look outside their own organizations to peers in other facilities. Facility tours can help facility managers better define their needs and narrow their alternatives. They can also prevent a project from proceeding too far down a dead end.

Data center infrastructure requirements

Because of their critical role in an enterprise, the cost of building and maintaining data centers and the amount of energy they consume, data center projects require special planning. Some organizations may choose to create separate management for data centers, but in many organizations, FM works with IT to ensure that the organization's data center design, construction and operation:

- Support optimal operation of the data center.
- Facilitate future upgrades and expansion.
- Support business continuity objectives in the event of disruptions.

The need for business continuity and the ability to provide uninterrupted data availability have to be balanced against the cost of achieving resiliency. So they must be designed to meet certain performance requirements and, before they go online, be thoroughly tested under different scenarios to ensure the desired level of reliability.

The complexity of infrastructure requirements for data centers is reflected in standards developed by the Telecommunication Industry Association (TIA), such as TIA-942-A and 568-C.



The standards' requirements address such issues as:

- Architecture.
- Electrical design.
- Cabling specifics.
- Storage specifics.
- Climate and lighting conditions.
- Energy efficiency.
- Protection against threats such as fire and flood.
- Security and control measures.

The Uptime[®] Institute's data center tiering standard can support management decision making about how much infrastructure the organization needs and can afford. The standard defines four tiers, each distinguished by an increasing level of resiliency and increasing infrastructure requirements. Each tier builds successively on the basic requirements for a Tier 1 data center: dedicated space with a cooling system that operates beyond normal business hours, a UPS and a generator in case of extended power outages.

Exhibit 6-35 on the next page summarizes the design topologies of each tier and the significance of the topology in terms of resiliency and operations. It also provides an example of the type of organization for whom this tier would be appropriate.

Tier assignments are only a general characterization, however. FM and IT should be wary about contractors who promise to deliver a "Tier-X" data center, or property sellers or lessors who claim a certain tier for an existing data center. Actual certification evidence can provide substantiation for claims.

FM must integrate the data center with facility processes and with the BAS. From an operational perspective, the importance of effective system design and maintenance in data centers cannot be overstated. Tier III and IV centers rely on effective planned and preventive maintenance that reduces the possibility of failure to near zero. Equipment and system maintenance and upgrades must be planned in collaboration with IT. The BAS must be tested to ensure that it generates alerts when needed, can track and document conditions for future analysis, identify problematic trends in component and system performance quickly, and can allow remote monitoring of conditions.



Exhibit 6-35: Data Center Tier Descriptions

Tier	Topology	Performance Factor
I	Single path of distribution for power and cooling with no redundancy	99.67 percent site availability (28.8 hours of outage due to planned maintenance or failure per year)
	Example: Small home health-care company that uses computers to perform internal processes and to host a passive online presence and facilitate e-mail	
II	Single path with redundant critical power and cooling capacity components (e.g., extra UPS modules, chillers, generators)	99.75 percent site availability (22 hours of outage due to planned maintenance or failure per year)
	Example: Online educational institution that uses IT to deliver materials and testing, maintain student records, perform third-party billing and fulfill compliance requirements. Periodic planned shutdowns are tolerable; frequent and prolonged unavailability is not.	
III	Multiple paths, only one active at the same time (as an alternate) with redundant components	99.98 percent site availability (1.6 hours unplanned outage per year) Concurrent maintenance is possible. (i.e., no downtime for planned site maintenance)
	Example: Legal firm with offices in multiple countries and time zones and an “around-the-clock, seven days a week” need for data/service availability. Temporary or planned unavailability can be managed, but risks financial penalties and loss of reputation.	
IV	Multiple and independent paths, both active at the same time Redundant systems with redundant components (which, in some cases, may be installed in remote locations or included as a comprehensive service by a vendor who accommodates multiple clients in disaster recovery centers)	99.99 percent site availability (0.8 hours unplanned outage per year) Concurrent maintenance is possible. (i.e., no downtime for planned site maintenance) Fault tolerant (i.e., system can sustain an unplanned event without disrupting users)
	Example: Large, global financial services business whose employees and clients may need to access account data and perform transactions at any time. Penalties for failure to perform transactions within a narrow time frame are severe. Potential for financial loss is great if information is not immediately available and transactions cannot be completed instantly.	

Source: W. Pitt Turner, IV, John H. Seader, Vince Renaud and Kenneth G. Brill. “Tier Classifications Define Site Structure Performance.” Uptime® Institute White Paper, 2008, www.greenserverroom.org/Tier%20Classifications%20Define%20Site%20Infrastructure.pdf.

Business case

To secure organizational resources in most instances, facility managers will need to present a business case to senior management. Business cases are discussed in more detail in the *Project Management* competency but generally include:

- The project’s scope and objectives
- Overview of the process in question and identification of all associated and dependent processes that may be affected by this project



- Needs that the projects answers
- SWOT (Strength/Weakness/Opportunity/Threat) analysis of alternatives identified
- Cost-effectiveness analysis, using a spreadsheet to compare various options with each other and/or with the cost of not doing anything:
 - If necessary, “what if” scenarios should be included—for example, how will the project team respond if a significant new technology becomes available during the project? How will this affect the costs assessment?
 - If necessary, the analysis should include sensitivity factors to indicate range in a value based on some uncertainty about the estimate used.
- Recommended solution
- Proposed next steps (implementation steps, schedules, budgets)
- Proposed metrics for evaluation of the project’s effectiveness

PDCA case studies: Planning

Three cases offered as examples by facility managers will be used in this topic to illustrate the application of the PDCA model to implementing a technology project. They include:

- Implementation of a CMMS by an educational facility.
- Database creation for a preventive maintenance workflow in a research facility.
- Implementation of a document tracking system in a law firm.

This first discussion of the case studies focuses on project planning.

PDCA Case Studies: Planning

CMSS implementation

The facility manager for a medical college campus identified specific shortcomings of the existing workflow process that was hindering performance of both facility management and the entire organization. Facility management could not access maintenance-related data in a manner that would support analysis and decision making. Without data on maintenance costs:

- Budgets could not be accurately predicted for coming periods.
- Performance against the current budget could not be tracked.
- The performance of equipment and systems could not be completed.

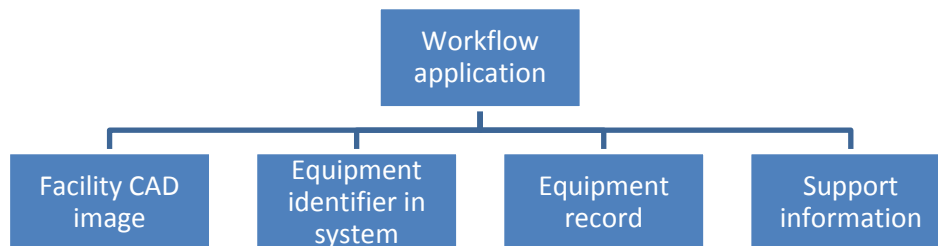
The project team then began the process of compiling equipment-related data to define more accurately the new system’s technical requirements. Users and clients of the current system were interviewed in depth to establish present and future needs for the maintenance function.

The team then began to research CMMS options. Cost and SWOT analyses were performed for different options.



Database creation for a preventive maintenance workflow application

The facility manager for an 180,000 sq. ft. facility with four buildings, combining office and labs, inherited an application that assigned preventive maintenance tasks to the facility's seven technicians. Sadly, equipment data had been entered sparingly into the system. No equipment file contained all the information desired, nor was the data searchable. The goal was to use internal staff to recreate a more effective database, one that would associate a facility CAD drawing, an application database record, a file of additional information and an equipment tag. This task is illustrated below.



The project was assigned to a knowledgeable technician with support from an administrator and other technicians. The plan was to proceed system by system (e.g., cooling, heating, water), completing one building at a time.

Implementation of a document tracking system

A law firm occupies ten floors of an office building and operates as well four satellite office in other parts of the country. The facility mailroom manages a large amount of correspondence in the form of internal and external mail and courier packages passing between the firm and its clients, experts, courts and adversaries and between the headquarters and satellite offices. Since this is the law, those documents are highly significant: they affect litigation and billing. A lost document is embarrassing for the firm and potentially expensive for clients.

FM then weighed the desire of legal staff to be able to work remotely on electronic documents against the reality of the amount of work that would be required to scan existing and future documents into a document management system. They decided a paperless system was a good goal but not feasible now. Still, they did not want to make investments that would take them further from this goal.

The next step was to quantify the costs of this "pain point" for the organization. This was accomplished by tracking mailroom hours spent searching for lost files. A justifiable budget could now be set and available products considered. FM met with vendors over a four-month period, rejecting some because they were too expensive and others because they were more appropriate for other industries. It was then discovered that the vendor for the firm's filing systems also sold a document tracking product that used bar codes. Managing partners, operations managers and lawyers all met the prospective vendor, and when they were satisfied, the project proceeded.



Do

During this project phase, budgets and timelines are created, and team members are selected. Project leaders should use available project management technology to develop, maintain and revise as needed budgets and schedules and to share information among the team. Payment schedules to vendors should be tied to meaningful and measurable project milestones.

Team management is critical. Team members should represent not only those with technical expertise but clients who have a vested interest in the project's outcome. Sales representatives and technical consultants from vendors should be part of the team as well, and the project leader must be alert to any disagreements or inconsistent messages from these two members.

It is the project manager's responsibility to ensure that all team members remain engaged in the project and perform their responsibilities. This can be a challenge when working with a virtual team on a global project. Regular video or Web conferencing can support team interaction. This means that project leaders must also be adept at running effective meetings. The *Communication* competency addresses some of these issues.

Roles, responsibilities and decision making authority must be defined, as should guidelines for:

- Communicating (e.g., what needs to be communicated in what time frame and to whom, and what issues merit escalation).
- Conflict resolution.
- Change order.
- Documentation.

The team should also be prepared for succession issues, since technology projects can span years. Documentation, such as a team charter, will help enormously in ensuring continuity in team activities as team members change.

A final point in this project phase: although team focus is directed intently at the project's goals, the team must remember that it is important to maintain contact with the rest of the organization during this time. It is easy to disappear, but during the team disappearance, clients may be forgetting what the team is actually working hard on accomplishing and what it will eventually mean to the clients and the organization. Periodic updates to those affected by the project can help retain support and a better reception at launch.



PDCA case studies: Doing

The three case study projects have proceeded into the next phase: defining and refining processes and selecting technological solutions .

PDCA Case Studies: Doing

CMMS project

The alternatives considered for the medical school campus were a CMMS integrated into an IWMS solution or a CMMS included in a maintenance service RFP. The maintenance service vendor proved a less expensive and more flexible option. The IWMS was robust but, given the cost, probably more than the organization needed. Purchasing the CMMS as a service meant that the facility would not be locked into a system that it was likely to outgrow quickly. Historical data would be owned by the facility. The service provider would assume responsibility for modifying the software to meet emerging facility needs. Based on FM's recommendation, senior management approved purchasing CMMS as a service. The service provider worked together with its client to import data into the system and to tailor it to the facility's requirements.

Workflow application

The process the team developed to improve their workflow system database was to:

- Update facility AutoCAD drawings to show blocks for each piece of equipment.
- Tag each block with a unique identifier in the system database.
- Print identifier tags to be placed on each piece of equipment and the corresponding file folder containing the equipment manuals.
- Update the record by placing equipment data in the proper fields.

One of the challenges was to find parallel information for each piece of equipment. For example, paper-based equipment folders did not always contain manuals, which necessitated a Web search to find and download an equivalent document.

Document tracking system

FM worked together with the vendor to define the organization's needs and customize the off-the-shelf product. This required coordinating three key actors: the mail room, legal administrators and the records library. For the project to work, each member would have to create, attach and scan bar codes for all documents. Documents would have to be scanned in as received within a certain time period. Otherwise the system would issue an alert that a document had been lost. In addition, the information to be included in the bar code had to be defined, and printing and scanning equipment acquired. The facility team decided to implement the system at the headquarters first, before rolling it out to the firm's satellite offices.



Check

Testing can help prevent launch or cutover disasters. When designing the project, team members should look for ways to test components separately and at earlier stages in development. The goal is to identify issues and possible improvements in a dynamic manner during development.

PDCA case studies: Checking

During this phase, the case study project teams focused on problem solving and testing to ensure a smooth rollout of the technology.

PDCA Case Studies: Checking

CMMS project

Evaluations of the project revealed two issues that were resolved before implementation:

- After data was entered into the CMMS database, additional equipment was identified and had to be added to the plan.
- Tests of the user experience of the system outputs revealed the need for customer work orders as an option in the system.

Workflow application

The project's completion was scheduled to occur in four stages, with completion of data files for one building each quarter. The team agreed that files for all equipment would be quality checked to ensure the accuracy and completeness of the new database. The project stayed on schedule, with support from other members of the facility management staff.

Document tracking system

In applying the new technology, the facility team uncovered several problems with the previous document tracking process. To ensure that the process was optimized before the new technology was introduced, the team formed a committee with representatives from different departments who would be responsible for the implementation and support of the system. The committee met weekly at first.

The physical aspects of the system were tested on a small number of cases that fairly represented the type of documents and document paths seen in the organization. The system appeared to work as promised by the vendor.

Act

The Act phase includes providing training, launching the technology, monitoring and evaluating its performance, and maintaining the technology going forward.

Training and support

Training must be designed for the technology's different audiences:

- IT personnel, who may need to support the technology after launch
- Facility management technicians, who need to know how to use it and where to turn for help. Technician training must take into account both



information about the new system and current technician skills levels. Does the new technology require skills the technicians generally lack? How will that gap be addressed?

- Clients, who need to know not how the technology works but how they interact with it—what actions they need to perform, what they should be receiving and where to turn for help.
- Future audiences—newcomers to the facility who will require training on the technology. Can the original training be repurposed for this audience? Can training be offered at intervals or “just in time”? Can training be accomplished through coaching or peer training?

The frequent use of the word “help” in the previous paragraph underscores the need for planning this component of the new technology. Who will provide support: the vendor, IT or facility management? How can support be accessed? When will it be available?

Launch

Facility managers should choose a launch date with thought. It should be realistic; repeated postponements will undermine the new technology’s credibility with management and with clients. New technology should be launched at a time of low stress for the organization. The launch date should be avoid peak work periods (e.g., end-of-quarter reports), introductions of other changes (e.g., installations of new equipment) or organizational events so that attention must be parceled out among competing issues.

The facility manager should take advantage of all ways to announce the launch of the new technology:

- Presentations to management and affected departments
- Facility newsletters
- Social media

For some projects it may make sense to communicate with professional organizations, the public media (e.g., journalists covering local businesses or the real estate market) and peers.

Post-launch activities

A system care process, including a maintenance contract with a vendor, must be implemented. An organized user community/committee should be established to support rapid report and resolution of issues and identify opportunities for improving the technology.

After an appropriate time period, the technology should be evaluated to determine whether it has delivered the promised value. Metrics identified in the



business case and modified during development should be used, and a report prepared for senior management. Clients and staff can be included in the evaluation report in a more informal manner, through e-mails or regular staff meetings.

Evaluation should also include another question: Is there anything here that could be done better? The answers to that question bring the project full cycle, as proposed improvements must be sold, developed, implemented and evaluated.

Any changes—from small fixes to major revisions—must be documented as defined in the appropriate SOP. This is the only way that the organization can manage its knowledge over time and ensure that knowledge does not exit the organization with an employee.

PDCA case studies: Acting

The case study projects have been implemented and the teams now focus on maintaining and improving the use of the technology.

PDCA Case Studies: Acting

CMMS project

The launch went well, except for the fact that training sessions were much larger than the team had anticipated. This meant that additional materials had to be produced quickly, and trainers had to revise their presentation methods on the spot. This could have compromised the quality of the training. The team noted this experience for future projects.

The project was evaluated in terms of on-time delivery, end-user experience and satisfaction, and the CMMS data entry process. Management liked the automated scheduling of preventive and non-emergency tasks, the ability to compile equipment histories and the flexible reporting features. For example, the facility manager could identify maintenance costs by building, room or piece of equipment. Technicians liked the fact that they could use smartphones and laptops at the job site to scan in bar codes on equipment and update status. Because the system monitored inventory levels and issued alerts when supplies were running low, technicians were rarely delayed by not having the right parts.

Workflow application

At the end of the year-long project, the team could celebrate its accomplishment. Immediately, however, the team began to plan further improvements to the system.



Document tracking system

A launch date was announced, and the system was rolled out throughout the organization. Almost immediately, problems were apparent. Bar codes were not working properly, some offices were experiencing log jams of documents waiting to be scanned in and out, and some attorneys were not as fully committed to the process as the managing partners had been. The rollout was stopped, the process reevaluated and the buy-in of all the attorneys and their administrators was secured.

This experience in itself turned out to be a benefit. The facility team had learned more about implementing complex processes that involved technology and human beings. The people proved harder to control than the technology.

Another unexpected benefit was the improved understanding of the firm's stakeholders that facility management acquired in the course of their weekly committee meetings. This strengthened working relationships and improved productivity.

Evaluation of the project's metrics was very encouraging. The number of missing files, the most important metric, dropped dramatically—from 20 to 23 requests per month for a missing file to only two or three requests. In addition, these searches were accomplished much more quickly.

The organization decided that it would apply what had been learned to its satellite offices so that it could expand the value of the technology to the entire organization.



Progress Check Questions

Directions: Read each question and respond in the space provided. Answers and page references follow the questions.

1. List at least three characteristics of an effective technology project.

2. Who can provide the best guidance concerning the implementation of a move management application? (*Choose one.*)

- ☐ a. A system vendor
- ☐ b. Senior management
- ☐ c. Facility management
- ☐ d. Department managers

3. Senior management must decide how to allocate resources for capital expenditures in the coming three-year period. Facility management proposes an EMS, but senior managers are not convinced that this is the best investment. How can facility management best persuade the C suite to invest in the EMS? (*Choose one.*)

- ☐ a. Explain the benefits of an EMS in a presentation to senior management.
- ☐ b. Perform a cost-benefit analysis of EMS and no-EMS scenarios.
- ☐ c. Perform a SWOT analysis of possible alternatives.
- ☐ d. Take senior management on a tour of facilities equipped with EMS.

4. What is the best reason for developing a project team charter and record of team decisions in a technology project? (*Choose one.*)

- ☐ a. Succession planning
- ☐ b. Control of project scope creep
- ☐ c. Conflict resolution
- ☐ d. Compliance

5. A cross-functional team, led by facility management, has implemented new technology to support more efficient move management, tested it in one department, trained all occupants in new SOPs concerning moves and the new software system, and rolled the new technology out to the entire organization. Within three months, several departments found the system did not answer their needs and were refusing to use the new system. How could this project have been implemented more effectively? (*Choose one.*)

- ☐ a. By choosing a different software vendor.
- ☐ b. By enlisting senior management support in bringing the rebellious departments into line.
- ☐ c. By including representatives from all departments in the technology's implementation.
- ☐ d. By testing the new technology and process in a greater number of departments.



6. In the move management project described in the previous question, what would have been appropriate metrics to evaluate the project's success? List at least three possible metrics.



Progress check answers

1. Characteristics of an effective technology project include ensured stakeholder buy-in; alignment with organizational needs and priorities; realistic assessment of the task and its requirements; an organization prepared and ready for the change; a foundation built on good processes; effective team communication; management of budget and schedule; good project documentation; well-planned implementation strategy; a plan for training included; use of appropriate metrics to evaluate results. (p. 6-111)
2. d. The best guidance will come from users in this case. Senior management can provide parameters, facility management can provide project structure and facilitate implementation, and vendors can provide expertise, but only the users know what they will have to do and the conditions under which it must operate effectively. (p. 6-112)
3. b. The best answer to management's question would be to quantify the cost savings of an EMS by projecting best estimates of energy costs with an EMS over a particular time period, and then comparing this with projected energy costs over the same period. (p. 6-118)
4. a. A charter that describes team roles and a historical record of what decisions were made and why they were made will produce a faster and more seamless transition for new team members. (p. 6-121)
5. d. The new system should have been tested in more than one department, since departments may vary in their practices and needs. Including every department on the team would have been impractical, but including the largest and most important (from the organization's point of view) would have been wise. (p. 6-123)
6. Possible metrics for this project might include on-schedule delivery, alignment with budget, user satisfaction, reduction in costs associated with moves, reduction in time needed to implement moves and reduction in furniture to be moved (p. 6-124).

Next Steps

You have completed this competency of the IFMA Facility Management Learning System. Next, check your understanding by completing the online competency-specific chapter quizzes and case study to help you identify any concepts that need additional study. Check your understanding another way by selecting the competency-specific eFlashcards, or visit the Resource Center to download printable flashcards. Then try applying the knowledge you have gained by completing the online case-study exercises.

Complete the post-test to check your understanding, and refer to the post-test report to determine competencies you may need to review. Repeat the post-test review process until you earn a post-test score of 80 percent or more. Each time you re-take the post-test, a new attempt is recorded in the system.

(continued on next page)



Next Steps, continued

When you have earned a post-test score of 80 percent or more, try the “Experience the Exam” practice test. This online test simulates the interface of the actual CFM Exam. It is designed as a final preparation prior to sitting for your CFM Exam. The Resource Center also includes test-taking tips to help you prepare.

Once you have completed all of the interactive online study tools and achieved your passing post-test score, you can print a Certificate of Completion for the learning system.

Please take a few moments to complete the short evaluation form available from the Resource Center. Your opinions will be used to help us improve the program for you and our future customers.



Cumulative Course Bibliography

The following resources were used during the development of the IFMA Facility Management Learning System.

“About the Green Building Initiative.” Green Building Initiative, www.thegbi.org/about-gbi.

Advanced Lighting Guidelines. White Salmon, Washington: New Buildings Institute, 2010.

Akbari, Hashem. “Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation.” Berkeley, California: Lawrence Berkeley National Laboratory, 2005.

Albinger, Don. “Accelerating Sustainability: Combining On-Site Renewables and Energy Efficiency to Fuel Economic, Environmental and Social Progress.” Milwaukee, Wisconsin: Johnson Controls, 2009.

Amabile, Teresa, and Steven Kramer. “How Leaders Kill Meaning at Work.” *McKinsey Quarterly*, January 2012.

American Gas Association. www.aga.org.

American Society for Quality (ASQ). *ASQ’s Foundations in Quality Learning Series: Certified Manager of Quality/Organizational Excellence*. Milwaukee, Wisconsin: ASQ, 2005.

Anderson, Brent. “Quality Assessment and Innovation.” Houston, Texas: International Facility Management Association (IFMA), 2006.

Anderson, Brent, Jeffrey L. Campbell, Carol E. Farren, Christopher P. Hodges, Jon Hosford, Scott Hulick, Diane H. MacKnight, Jon Martens, Anne M. Moser and James P. Whittaker. “The Business of FM.” Houston, Texas: International Facility Management Association (IFMA), 2006.

Ansari, Shahid, and Carol Lawrence. *Cost Measurement Systems: Traditional and Contemporary Approaches*. New York: Irwin/McGraw Hill, 1999.

Anthony, Robert N., and Vijay Govindarajan. *Management Control Systems*, 11th edition. New York: Irwin/McGraw Hill, 2004.

APICS (The Association for Operations Management). *APICS Certified Supply Chain Professional Learning System*, V2.1. Chicago, Illinois: APICS, 2010.

Arnold, Jennifer Taylor. “Kicking Up Cross-Training.” *HR Magazine*, Vol. 53, No. 8, August 1, 2008.

Arnold, Shad. “Lighting: Illuminating the Path to Savings,” in *Cut It Out!* Houston, Texas: IFMA Foundation, 2009.



- Ashkin, Stephen, and David Holly. *The Business of Green Cleaning*. Houston, Texas: IFMA Foundation, 2008.
- “Asset Lifecycle Model for Total Cost of Ownership Management—Framework, Glossary and Definitions.” www.ifma.org/know-base/fm-knowledge-base/knowledge-base-details/asset-lifecycle-model-for-total-cost-of-ownership-management.
- The Associated Press Style Book*. New York: Basic Books, 2004.
- ASTM International. ASTM E1836/E1836M-09e1, “Standard Practice for Building Floor Area Measurements for Facility Management.” ASTM International: West Conshohocken, Pennsylvania.
- ASTM International. *ASTM Standards for Whole Building Functionality and Serviceability*, 3rd edition. West Conshohocken, Pennsylvania: ASTM International, 2009.
- Atkin, Brian, and Adrian Brooks. *Total Facilities Management*, 3rd edition. Chichester, United Kingdom: Wiley-Blackwell, 2009.
- Attwood, Dennis A. *The Office Relocation Sourcebook: A Guide to Managing Staff Throughout the Move*. New York: John Wiley and Sons, 1996.
- Austin, John, David B. Hatfield, Angelica C. Grindle and Jon S. Bailey. “Increasing Recycling in Office Environments: The Effects of Specific Informative Cues.” *Journal of Applied Behavior Analysis*, Summer 1993.
- Ayers, David. “Contractor Safety: Building Trust and Communication.” *EHS Today*. October 1, 2007. ehstoday.com/mag/contractor_safety_building.
- Baker, H. Kent, and Gary E. Powell. *Understanding Financial Management: A Practical Guide*. Malden, Massachusetts: Blackwell Publishing, 2005.
- “Balanced Scorecard.” www.ifma.org/about_ifma/strategic_plan/bsc.cfm.
- “Balanced Scorecard Basics.” Balanced Scorecard Institute, www.balancedscorecard.org/BSCResources/AbouttheBalancedScorecard/tabid/55/Default.aspx.
- Barnatt, Christopher. “Green Computing.” August 2011. www.explainingcomputers.com/green.html.
- Barnes, Aimee. “REC vs. Carbon Offset: Do You Know the Difference?” March 12, 2009, www.greenbiz.com/blog/2009/03/12/rec-vs-carbon-offset-do-you-know-difference.
- Barnes, Robert, Yashesh Shah and Kathy Roper. *Facility Management Career Framework*. White paper prepared for IFMA. June 2010.
- Barringer, H. Paul. “A Life Cycle Cost Summary.” Barringer and Associates, Inc., 2003, www.barringer1.com/pdf/LifeCycleCostSummary.pdf.
- Barry, John J. “IFRS and U.S. GAAP Similarities and Differences.” IFRS Readiness Series. PriceWaterhouseCoopers, 2009.



- Bast, Joseph L., Peter J. Hill and Richard C. Rue. *Eco-Sanity: A Common-Sense Guide to Environmentalism*. Lanham, Maryland: Madison Books, 1994.
- Baue, Bill. "Some Applaud Rise in Sustainability Reporting, Others Say It Masks Corporate Un-Sustainability," July 11, 2006, www.socialfunds.com/news/print.cgi?sfArticleId=2054.
- Bauer, John E., Grace L. Duffy and Russell T. Westcott, editors. *The Quality Improvement Handbook*, 2nd edition. Milwaukee, Wisconsin: ASQ Quality Press, 2006.
- Beard, Colin, and Ifryn Price. "Space, Conversations and Place: Lessons and Questions from Organizational Development." *International Journal of Facility Management*, November 2010.
- Belbin, R. Meredith. *Team Roles at Work*, 2nd edition. Burlington, Massachusetts: Elsevier, 2010.
- Benya, James R. "Controlling Glare." *Architectural Lighting*, March 1, 2010, www.archlighting.com/industry-news.asp?articleID=1237963.
- Berry, Leonard L., Ann M. Mirabito and William B. Baun. "What's the Hard Return on Employee Wellness Programs?" *Harvard Business Review*, December 2010.
- "Best Management Practice: Boiler/Steam Systems." U.S. Department of Energy, March 2010, www1.eere.energy.gov/femp/program/waterefficiency_bmp8.html.
- "BetterBricks' High Performance Hospital Partnership: Guide to Optimizing Hospital Facility Investments." Better Bricks—The Northwest Energy Efficiency Alliance (NEEA).
- Bigger, Alan S., and Casey J. Wick, editors. *Operational Guidelines for Educational Facilities: Custodial*. Alexandria, Virginia: APPA, 2011.
- "Biophilic Design." *Ultimate Home Design*, July/August 2006, www.ultimatehomedesign.com/oph/uhd04gb02.pdf.
- Birt, Benjamin J., and Guy R. Newsham. "Post-Occupancy Evaluation of Energy and Indoor Environment Quality in Green Buildings: A Review." June 2009, archive.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc51211.pdf.
- Blake, Gary, and Robert Bly. *The Elements of Business Writing*. New York: Longman, 1991.
- Blake, Robert Rogers, and Jane Srygley Mouton. *The New Managerial Grid*. Houston, Texas: Gulf Publishing Company, 1978.
- Blocher, Edward J., Kung H. Chen and Thomas W. Lin. *Cost Management: A Strategic Emphasis*, 2nd edition. New York: Irwin/McGraw Hill, 2002.
- "BMS and the Data Center." *The Data Center Journal*, July 2012, www.datacenterjournal.com/facilities/bms-and-the-data-center.
- "BOMA Measurement Standards." www.boma.org/measurementstandards/pages/default.aspx.



“Brand, Culture and the Workplace.” 360 White Paper. June 2010, 360.steelcase.com/white-papers/brand-culture-and-the-workplace.

“Brands and Carbon Offsets.” Carbon Offsets Daily, August 1, 2008, www.carbonoffsetsdaily.com/lists/brands-providing-carbon-offsets.

Branscomb, Lewis M., Kenneth P. Morse, Michael J. Roberts and Darin Boville. *Managing Technical Risk*. NIST, April 2000.

BREEAM (Building Research Establishment Environmental Assessment Method), www.breeam.org.

Brown, Brad, Michael Chui and James Manyika. “Are You Ready for the Era of ‘Big Data’?” *McKinsey Quarterly*, October 2011.

Brown, Mark Graham. *Keeping Score: Using the Right Metrics to Drive World-Class Performance*. Portland, Oregon: Quality Resources, 1996.

Brown, Mark Graham. *Winning Score: How to Design and Implement Organizational Scorecards*. New York: Productivity Press, 2000.

Bruner, Robert F., et al. *The Portable MBA*, 4th edition. Hoboken, New Jersey: John Wiley and Sons, 2003.

Bughin, Jacques, Angela Hung Byers and Michael Chui. “How Social Technologies Are Extending the Organization.” *McKinsey Quarterly*, November 2011.

Bughin, Jacques, Michael Chui and James Manyika. “Clouds, Big Data, and Smart Assets: Ten Tech-Enabled Business Trends to Watch.” *McKinsey Quarterly*, August 2010.

“Building a Safer Workplace.” Towers Watson, 2010. www.towerswatson.com/assets/pdf/1353/Safety_Culture_Brochure_TW_Final.pdf.

“Building Air Quality.” U.S. Environmental Protection Agency and Centers for Disease Control, December 1991.

The Building Commissioning Guide. U.S. General Services Administration, Public Buildings Services, 2005.

“Building Energy Retrofit Program.” Building Owners and Managers Association International and Clinton Climate Initiative.

Building Owners and Managers Association International and International Facility Management Association. “A Unified Approach for Measuring Office Space for Use in Facility and Property Management.” 2007.

“Buildings and Climate Change: Summary for Decision-Makers.” United Nations Environment Programme Sustainable Buildings and Climate Initiative, 2009, www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf.



- Buildings Energy Data Book*. U.S. Department of Energy, October 2009, buildingsdatabook.eren.doe.gov/docs/DataBooks/2009_BEDB_Updated.pdf.
- “Buildings Matter.” Royal Institute of British Architects, www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/PublicAffairs/BuildingsMatter.pdf.
- Business Continuity Institute, www.thebci.org.
- “Business Contracts Legal Terms and Definitions Glossary,” www.businessballs.com/businesscontractstermsdefinitions glossary.htm.
- Business Link (U.K. government Web site for businesses), www.businesslink.gov.uk/bdotg/action/home?domain=www.businesslink.gov.uk&target=http://www.businesslink.gov.uk.
- “Business Role: Corporate Social Responsibility.” World Business Council for Sustainable Development, www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=MTE0OQ.
- The Business Value of BIM*. SmartMarket Report. McGraw-Hill Construction, 2009.
- The Business Value of BIM in Europe*. SmartMarket Report. McGraw-Hill Construction, 2010.
- “Buying a Better World: Sustainable Public Procurement.” Forum for the Future, December 2007, www2.aashe.org/heasc/documents/BuyingaBetterWorld.pdf.
- “CALiPER Program.” U.S. Department of Energy, www1.eere.energy.gov/buildings/ssl/caliper.html.
- Camp, Robert C. *Benchmarking: The Search for Industry Best Practices That Lead to Superior Performance*. Milwaukee, Wisconsin: ASQ Quality Press, 1989.
- Camp, Robert C. *Business Process Benchmarking: Finding and Implementing Best Practices*. Milwaukee, Wisconsin: ASQ Quality Press, 1995.
- Campbell, Jeffery L. *Facility and Property Management Guidebook*, 2nd edition. Orem, Utah: Campbell Consulting Group, 2011.
- Campbell, Jeffery L. *Real Estate for Facility Managers. An IFMA Competency-Based Course*. Houston, Texas: International Facility Management Association (IFMA), 2006.
- “Carbon Offsets.” U.S. Government Accountability Office, August 2008.
- “Carbon Offsets: Sins of Emission.” *The Economist*, August 3, 2006, www.economist.com/node/7252897?story_id=7252897.
- “Carbon 101—Carbon Markets, Terminology, Buyers and Sellers.” Axiom Methods, January 29, 2009, www.axiommethods.com/market/carbon101.pdf.
- Carey, Raissa. “The Quality Profession: A Report, an Idea, and the Truth—An Interview with H. James Harrington,” www.qualitydigest.com/inside/quality-insider-article/report-idea-and-truth.html.



Carroll, Archie B., and Ann K. Buchholtz. *Business and Society: Ethics and Stakeholder Management*, 7th edition. Mason, Ohio: South-Western Cengage Learning, 2009.

“Case Studies: Interactive Case Studies in Sustainable Community Development.”
Community Research Connections, www.crcresearch.org/case-studies.

Centers for Disease Control and Prevention. “Emergency Preparedness and Response: Crisis and Emergency Risk Communication.” www.bt.cdc.gov/cerc.

“The Challenge of Sustainability: An Action Agenda for the Global Environment.” Global Environment Facility, 2002, www.thegef.org/gef/sites/thegef.org/files/publication/The.Challenge.of_.Sustainability.pdf.

“Characterization of Building Related Construction and Demolition Debris in the United States.” U.S. Environmental Protection Agency, 1998.

“Chemicals in the Workplace.” International Labour Organization, actrav.itcilo.org/actrav-english/telearn/osh/kemi/ciwmain.htm.

The Chicago Manual of Style, 16th edition. Chicago: University of Chicago Press, 2010.

CIBSE Guide B2. London: Chartered Institution of Building Services Engineers, 2001.

Clayton, John. “Crafting a Powerful Executive Summary.” Harvard Business School *Working Knowledge*, hbswk.hbs.edu/archive/3660.html.

“Climate Change Enclosed: Junk Mail’s Impact on Global Warming.” ForestEthics.org, www.donotmail.org/article.php?id=119.

“Climate Change 2007.” Intergovernmental Panel on Climate Change, November 2007, www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm.

Coleman, Mark. “Communicating Your Corporate Sustainability Strategy.” www.evancarmichael.com/Going-Green/3801/Communicating-Your-Corporate-Sustainability-Strategy.html.

Coles, Diane, and Georgia Perkey. “The Paper Trail: Follow the Paper—Find the Money,” in *Cut It Out!* Houston, Texas: IFMA Foundation, 2009.

“Combined Heat and Power Partnership (CHP).” U.S. Environmental Protection Agency, www.epa.gov/chp.

“Common Carbon Metric.” United Nations Environment Program, Sustainable Buildings and Climate Initiative, www.unep.org/sbci/pdfs/UNEPSBCICarbonMetric.pdf.

“Common Opportunities.” BetterBricks, 2009, betterbricks.com/DetailPage.aspx?ID=492.

The Communication Competency Course. An IFMA Competency-Based Course. Houston, Texas: International Facility Management Association (IFMA), 2006.



- “Comprehensive Assessment of Water Management in Agriculture 2007.” London: Earthscan and Colombo: International Water Management Institute, 2007, www.iwmi.cgiar.org/assessment/.
- Conley, Bill. *Lighting Solutions*. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2010.
- Continuity Guidance Circular 1 (CGC 2). Federal Emergency Management Agency, January 21, 2009, www.fema.gov/about/org/ncp/coop/planning.shtm.
- Continuity Guidance Circular 2 (CGC 2). Federal Emergency Management Agency, July 22, 2010, www.fema.gov/about/org/ncp/coop/planning.shtm.
- Continuous CommissioningSM Guidebook for Federal Energy Managers*. U.S. Department of Energy, 2002.
- Cook, Claire Kehrwald. *Line by Line: How to Improve Your Own Writing*. Boston: Houghton Mifflin Company, 1985.
- Cool Roof Rating Council, www.coolroofs.org.
- “Cool Roofs and Emissivity.” U.S. Environmental Protection Agency and Department of Energy, www.energystar.gov/index.cfm?c=roof_prods.pr_roof_emissivity.
- Corbett-Schramo, Jennifer. “Thinking Outside of the Bucket,” in *Cut It Out!* Houston, Texas: IFMA Foundation, 2009.
- Co-operators Youth Conference for Sustainability Leadership. www.impactyouthsustainability.ca/en.
- Cornel, Rosario, and Mark Sekula. *The Facility Manager’s Field Guide*. CorMark Publishing, 2011.
- Cosaboon, David, Edward J. Jarger, Gary Klein, Patrick Okamura, Mike Warren and Rob Zimmerman. *A Comprehensive Guide to Water Conservation: The Bottom Line Impacts, Challenges and Rewards*. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2010.
- “The Cost of Invasive Alien Species to Uganda.” National Agricultural Research Organisation (NARO), July 2004, www.naro.go.ug/Invasivespecies/Reports/Cost%20of%20Invasive%20Alien%20Species%20to%20Uganda.pdf.
- Cost Planning and Estimating for Facilities Maintenance*. Kingston, Massachusetts: RSMeans, 1996.
- Cottrell, David. *Monday Morning Leadership: Eight Mentoring Sessions You Can’t Afford to Miss*. Dallas, Texas: Cornerstone Leadership Institute, 2002.
- Cotts, David, and Edmond P. Rondeau. *The Facility Manager’s Guide to Finance and Budgeting*. New York: AMACOM, 2003.



Cotts, David, Kathy O. Roper, and Richard P. Payant. *Facility Management Handbook*, 3rd edition. New York: AMACOM, 2010.

Covey, Stephen. *The Seven Habits of Highly Effective People*. New York: Simon and Schuster, 1989, 1992.

“Cradle to Cradle: Certification Overview.” McDonough Braungart Design Chemistry (MBDC). www.mbdc.com/detail.aspx?linkid=2&sublink=8.

Craighead, Geoff. *High-Rise Security and Fire Life Safety*, 3rd edition. Boston: Butterworth-Heinemann/Elsevier, 2009.

“Creating Community.” Sustainable Communities Online, www.sustainable.org/creating-community.

Crisis Communication Planning Workbook. The Center for Biopreparedness Education, Creighton University Medical Center and University of Nebraska Medical Center, www.preped.org/resources/crisiscommunication-workbook.pdf.

Currier, Guy. “2012 Top Ten Business Trends.” November/December 2011, www.baselinemag.com.

Custodial Staffing Guidelines, 2nd edition. Alexandria, Virginia: APPA, 2008.

Cut It Out! Houston, Texas: IFMA Foundation, 2009.

“The Data Centre Future Is Green with Fiber Optics.” *CXO*, August 2008, www.cxo.eu.com/article/The-data-centre-future-is-green-with-fibre-optics.

“Demand Response and the Smart Grid.” Energy University (Schneider Electric) online course, 2009, www.schneider-electric.com/corporate/en/products-services/training/energy-university/energy-university-course.page.

“Demand Response, Smart Grid and Climate Change.” Demand Response and Smart Grid Coalition, 2007, www.drsgcoalition.org/resources/factsheets/Demand_Response_and_Climate_Change.pdf.

“Demand-Controlled Ventilation Using CO₂ Sensors.” Federal Energy Management Program, 2004, www1.eere.energy.gov/femp/pdfs/fta_co2.pdf.

Department for Environment, Food and Rural Affairs (U.K.), ww2.defra.gov.uk/environment.

“Department of Defense Green Procurement Strategy: Promoting Environmental Stewardship throughout the Department of Defense.” U.S. Department of Defense, 2008.

“Design for the Changing Workplace.” Whole Building Design Guide Productive Committee, 2009, www.wbdg.org/design/design_change.php.

“Developing Your Stormwater Pollution Prevention Plan.” U.S. Environmental Protection Agency, www.epa.gov/npdes/pubs/industrial_swppp_guide.pdf.



- Dinsmore, Paul, and Jeannette Cabanis-Brewin. *AMA Handbook of Project Management*, 2nd edition. New York: AMACOM, 2006.
- “Distributed Work.” IFMA Research Report #31. Houston, Texas: International Facility Management Association, 2009.
- Doonan, Christine, Jim Volkman, Alan Kakaley and Brad L. Weaver. *No-Cost/Low-Cost Energy Savings Guide*. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2010.
- Doty, Steve, and Wayne C. Turner. *Energy Management Handbook*, 7th edition. Lilburn, Georgia: The Fairmont Press, 2009.
- Dreibelbis, Bill, and Connie Brumgard. “Indoor Air Quality Studies,” PowerPoint presentation, www.ehs.psu.edu/help/info_sheets/Indoor_Air_Quality.ppt.
- “Driving to Green Buildings: The Transportation Energy Intensity of Buildings.” *Environmental Building News*. September 1, 2007, www.buildinggreen.com/auth/article.cfm/2007/8/30/Driving-to-Green-Buildings-The-Transportation-Energy-Intensity-of-Buildings.
- Duke, Kelly, and Matson Walter. “The Role of Landscaping,” in *Cut It Out!* Houston, Texas: IFMA Foundation, 2009.
- Earth Care, www.earthcare.org.
- Eastman, Chuck, Paul Teicholz, Rafael Sacks and Kathleen Liston. *BIM Handbook*. Hoboken, New Jersey: John Wiley and Sons, 2008.
- Eco-Cycle.org. www.eco-cycle.org.
- “Economic Benefits of Green Building Design and Construction.” PowerPoint presentation, www.calrecycle.ca.gov/Greenbuilding/Design/EcoBenefits.ppt#2.
- Education Resources Information Center, www.eric.ed.gov.
- Edwards, Paul. “Toward Agreed Metrics.” May 2010, www.unep.org/sbci/pdfs/SYM2010-SBCI_Symposium_PanelSB_PE.pdf.
- “Electricity/Heat in World in 2008.” International Energy Agency, www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=29.
- Elkington, John. *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*. Vancouver: New Society Publishers, 1998.
- “Emergency Preparedness 2011: Ten Years Later.” IFMA. www.ifma.org/docs/surveys/emergency_preparedness_survey_results_sept_2011.pdf?sfvrsn=2.
- EN 15221-7, “Facility Management—Guidelines for Performance Benchmarking.” European Committee for Standardization (CEN), 2012.



“Energy Efficiency in Buildings: Transforming the Market.” World Business Council for Sustainable Development, 2009, www.wbcsd.org/DocRoot/rVDgBRKvPngUrqivMHNM/91719_EEBReport_WEB.pdf.

“Energy Glossary.” California Energy Commission, www.energy.ca.gov/glossary/glossary-d.html.

Energy Management Systems. Portland Energy Conservation, Inc., October 1997.

“Energy Performance Contracting Financing Options.” Clinton Climate Initiative, April 2009, www2.presidentsclimatecommitment.org/documents/ccitoolkit/Energy_Performance_Contracting_Financing_Options.pdf.

“Energy Savers: Hydropower or Hydroelectric Power.” U.S. Department of Energy, www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10480.

ENERGY STAR, U.S. Environmental Protection Agency and U.S. Department of Energy, www.energystar.gov.

- “About ENERGY STAR,” www.energystar.gov/index.cfm?c=about.ab_index.
- “Frequently Asked Questions (FAQs),” www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_faq.
- “Guidelines for Energy Management Overview.” www.energystar.gov/index.cfm?c=guidelines.guidelines_index.
- “History of ENERGY STAR,” www.energystar.gov/index.cfm?c=about.ab_history.

EPA’s ENERGY STAR Portfolio Manager. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2009.

Epstein, Shari F. “Benchmarks V, Annual Facility Costs—Research Report #30.” Houston, Texas: International Facility Management Association (IFMA), 2008.

“Exploring the Current Trends and Future Outlook for Facility Management.” IFMA, 2011.

Falkin, Steve, and William Sellers. *Wireless Systems in the Facility*. Houston, Texas: IFMA Foundation, 2005.

Fanelli, Richard F., and Kirt Miller. *Planning and Project Management: An IFMA Competency-Based Course*. Houston, Texas: International Facility Management Association (IFMA), 2006.

“Fast Facts on Energy Use.” ENERGY STAR, www.energystar.gov/ia/business/challenge/learn_more/FastFacts.pdf.

Federal Emergency Management Agency. www.fema.gov.

“Federal Energy Management Program Fact Sheet.” U.S. Department of Energy, July 2005.

Fee, Edie. “Energy Savings,” in *Cut It Out!* Houston, Texas: IFMA Foundation, 2009.



- Finance and Business Essentials*. Houston, Texas: International Facility Management Association (IFMA), 2010.
- Finch, Edward, editor. *Facilities Change Management*. Chichester, United Kingdom: Wiley-Blackwell, 2012.
- Fisher, Graham. "Think Grey Water." FMLink, www.fmlink.com/article.cgi?type=Magazine&pub=Premises%20&%20Facilities%20Management&id=30892&mode=source.
- Fisher, Roger, and William Ury. *Getting to Yes: Negotiating Agreement Without Giving In*. New York: Penguin Books, 1991.
- "Fix a Leak Week." U.S. Environmental Protection Agency, www.epa.gov/WaterSense/pubs/fixleak.html.
- Florczak, Clifford M., and James E. Roughton. *Hazardous Waste Compliance*. Boston: Butterworth-Heinemann, 2001.
- "FM Sustainability: Creating Your Action Plan" (online course). Houston, Texas: International Facility Management Association (IFMA).
- Food and Agriculture Organization of the United Nations, www.fao.org.
- "Footprint Basics." Global Footprint Network, www.footprintnetwork.org/en/index.php/GFN/page/basics_introduction.
- "Fortifying the Foundation: State of the Voluntary Carbon Markets 2009." Ecosystem Marketplace and New Carbon Finance, www.ecosystemmarketplace.com/documents/cms_documents/StateOfTheVoluntaryCarbonMarkets_2009.pdf.
- "Frequently Asked Questions" (Green Globes), www.greenglobes.com/about-faq.asp.
- Friday, Stormy. *Organizational Development for Facility Managers: Tracing the DNA of FM Organizations*. New York: AMACOM, 2003.
- Friday, Stormy, and David G. Cotts. *Quality Facility Management: A Marketing and Customer Service Approach*. New York: John Wiley and Sons, 1995.
- Fuller, Sieglinde. "Life-Cycle Cost Analysis (LCCA)." National Institute of Standards and Technology (NIST), www.wbdg.org/resources/lcca.php.
- "Full-Spectrum Light Sources." Lighting Research Center, www.lrc.rpi.edu/programs/nlpiip/lightinganswers/fullspectrum/claims.asp.
- The Gallup Europe Journal Newsletter*. December 2007, www.gallup-europe.be/newsletter/articles/1207_18.htm.
- Garrison, Ray H., and Eric W. Noreen. *Managerial Accounting*, 10th edition. Boston: McGraw Hill/Irwin, 2003.



- “Geographic Information Systems (GIS) for Facility Management.” Houston, Texas: IFMA Foundation, 2010.
- Giorgino, Michael. “Remembering Rick Rescorla: A Hero on 9/11.” *San Diego Daily Transcript*, September 8, 2011, www.sddt.com.
- Glavinich, Thomas. *Contractor’s Guide to Green Building Construction*. Hoboken, New Jersey: John Wiley, 2008.
- Glendon, Lee. “Prioritizing Supply Chain Resilience.” *Continuity*, November/December 2011, www.thebci.org.
- “Global Diversity and Inclusion: Fostering Innovation through a Diverse Workforce.” *Forbes Insights*, July 2011, images.forbes.com/forbesinsights/StudyPDFs/Innovation_Through_Diversity.pdf.
- “Global Economic Prospects.” The World Bank Group, 2010, web.worldbank.org/external/default/main?theSitePK=659149&pagePK=2470434&contentMDK=20370063&menuPK=659159&piPK=2470429.
- Global Reporting Initiative. www.globalreporting.org.
- “Globally Harmonized System of Classification and Labelling of Chemicals (GHS).” UN Economic Commission for Europe, www.unece.org/trans/publications/dg_ghs.html.
- “The Good Practice Guide to Implementing a Sustainability Policy.” British Institute of Facilities Management, November 2008, www.bifm.org.uk/bifm/knowledge/resources/goodpracticeguides#jump_Sustainability.
- Good Practice Highlights 2010*. The Business Continuity Institute.
- Grant Thornton LLP and UGL Services, a division of UGL Limited of Sydney, Australia. *FASB Lease Accounting Article Series*, www.grantthornton.com/www.ugl-equis.com.
- “Operating” Leases Moving to the Balance Sheet, October 2009.
 - “Principles-Based Accounting for Leases,” October 2009.
 - “The Future of Leasing,” November 2009.
 - “The Lessor’s Perspective on Lease Accounting,” May 2010.
- Grantham, Charles, and James Ware. “The Office: A New Look at an Old Friend,” in *Cut It Out!* Houston, Texas: IFMA Foundation, 2009.
- “Green Building Basics.” California Department of Resources Recycling and Recovery, calrecycle.ca.gov/Greenbuilding/Basics.htm.
- “Green Building in North America: Opportunities and Challenges.” Commission for Environmental Cooperation (CEC), 2008, www.cec.org/files/PDF//GB_Report_EN.pdf.
- Green Building: Project Planning and Cost Estimating*, 2nd edition. Kingston, Massachusetts: RSMeans, 2006.



- “Green Buildings + Climate Change.” November 2008, BDCnetwork.com.
- “Green Cleaning: By the Numbers.” planetgreen.discovery.com/go-green/green-cleaning/green-cleaning-statistics.html.
- “Green Globes.” Green Building Initiative, www.thegbi.org/green-globes/default.asp.
- “Green Globes® Continual Improvement of Existing Buildings.” Green Building Initiative, www.thegbi.org/green-globes/continual-improvement-for-existing-buildings.asp.
- “Green Rating.” PowerPoint presentation, Bureau Veritas, 2010.
- Green Rating Systems Sustainability Guide*. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2010.
- “Green Roofs/Eco-Roofs.” Florida Field Guide to Low Impact Development, University of Florida Program for Resource Efficient Communities, 2008, buildgreen.ufl.edu/Fact_sheet_Green_Roofs_Eco_roofs.pdf.
- “Greenhouse Gas Inventory and Tracking in Portfolio Manager.” U.S. Department of Energy, August 31, 2009, www.energystar.gov/ia/business/evaluate_performance/Emissions_Supporting_Doc.pdf.
- “Greening California’s Leased Office Space: Challenges and Opportunities.” California Sustainability Alliance, May 5, 2009. sustainca.org/sites/default/files/GreenLeases_report_050509.pdf.
- Greening Federal Facilities*, 2nd edition. U.S. Department of Energy, 2001.
- Grogan, Terry. “Solid Waste Reduction in U.S. Hospitals—Case Studies.” *Business Briefing: Hospital Engineering and Facilities Management*, 2003, www.touchbriefings.com/pdf/13/hosp031_p_GROGAN.PDF.
- Grossman, Ben. “Green Is Lean: An Inside Look at Sustainable Purchasing at DHL Americas.” July 26, 2010, sustainableink.org/2010/07/26/green-is-lean-an-inside-look-at-sustainable-purchasing-at-dhl-americas/.
- GSA BIM Guide for Facility Management*. December 2011, www.gsa.gov/bim.
- GSA BIM Guide for 3D Imaging*. January 2009, www.gsa.gov/bim.
- GSA BIM Guide Overview*. May 2007, www.gsa.gov/bim.
- Guevarra, Leslie. “Gen Y’s Green Demands for the Workplace.” May 5, 2010, www.greenbiz.com/news/2010/05/19/gen-y-green-demands-workplace.
- “A Guide to Waste Reduction at Shopping Centers.” U.S. Environmental Protection Agency, 2004, www.epa.gov/osw/conserve/rrr/rogo/documents/amrguide/amrguide.pdf.
- Gustafson, S.W., et al. *Sustainable Landscaping*. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2010.



- Hagan, Philip. "What Factors Can Affect an Indoor Environmental Quality Complaint?" *Keeping Buildings Healthy*. New York: Wiley and Sons, 1998.
- Hall, Robert. "Making Success Out of a Crisis." *Continuity*, November/December 2011, www.thebci.org.
- Harris, Gardiner, and Heather Timmons. "Half of India Crippled by Second Day of Power Failures." *New York Times*, July 31, 2012.
- Harvard Business Essentials. *Finance for Managers*. Boston: Harvard Business School Press, 2002.
- Harvard Business Essentials. *Power, Influence and Persuasion*. Boston: Harvard Business School Press, 2005.
- Harvard Business Review Guide to Making Every Meeting Matter*. Harvard Business School Publishing Corporation, 2011, www.hbr.org.
- Harvard Business Review on Communicating Effectively*. Boston: Harvard Business School Publishing Corporation, 2011.
- Harvard Business Review School Press on Business Communication*. Boston: Harvard Business School Publishing Corporation, 2003.
- Hayes, Bob E. *Measuring Customer Satisfaction: Survey Design, Use, and Statistical Analysis Methods*, 3rd edition. Milwaukee, Wisconsin: ASQ Quality Press, 2008.
- Heath, Chip, and Dan Heath. *Made to Stick*. New York: Random House, 2007.
- Heerwagen, Judith, Kevin Kelly and Kevin Kampschroer. "The Changing Nature of Organizations, Work, and Workplace." February 2006, www.wbdg.org/resources/chngorgwork.php.
- Heinz, John A., and Richard B. Casault. *The Building Commissioning Handbook*, 2nd edition. Alexandria, Virginia: APPA, 2004.
- Herter, K., S. Wayland and J. Rasin. "A Successful Case Study of Small Business Energy Efficiency and Demand Response with Communicating Thermostats." Lawrence Berkeley National Laboratory, August 2009, drcc.lbl.gov/pubs/lbnl-2743e.pdf.
- Herzberg, Frederick, Bernard Mausner and Barbara Bloch Snyderman. *The Motivation to Work*. New York: John Wiley and Sons, Inc., 1959.
- "The High Performance Portfolio: Rethinking Simple Payback Period." www.betterbricks.com/graphics/assets/documents/ReThinking_Simple_Payback_9.09.pdf.
- Hitchcock, Darcy, and Marsha Willard. *The Business Guide to Sustainability*, 2nd edition. London: Earthscan, 2009.



- Hodges, Christopher. *Getting Started*. Sustainability “How-To Guide” Series. Houston, Texas: IFMA Foundation, 2010.
- Hodges, Christopher. *Operations and Maintenance: An IFMA Competency-Based Course*. Houston, Texas: International Facility Management Association (IFMA), 2005.
- Hodges, Christopher. “The Sustainability Scorecard—Developing Key Performance Indicators to Measure Sustainable Operations in Existing Buildings.” IFMA workshop presented to Kansas City chapter, February 19, 2009.
- Hoekstra, A.Y. “Value of Water Research Report Series No. 28.” UNESCO-IHE Institute for Water Education, March 2008.
- Hoeller, Peter, and Markku Wallin. “Energy Prices, Taxes and Carbon Dioxide Emissions.” Autumn 1991, www.oecd.org/dataoecd/33/26/34258255.pdf.
- Hohmann, Joachim W., Geoff Williams and Michael May. *Facility Automation: Between Myth and Mythology*. IFMA World Workplace, 2008.
- Homans, George C. *The Human Group*. London: Routledge & Kegan Paul Ltd., 1951.
- “Homeland Security Exercise and Evaluation Program (HSEEP).” U.S. Department of Homeland Security, February 2007. hseep.dhs.gov/pages/1001_HSEEP7.aspx.
- Hooker, John. “Cultural Differences in Business Communication.” Tepper School of Business, Carnegie Mellon University, December 2008, john@hooker.tepper.cmu.edu.
- Hoots, Michael L. *Finance for Facility Managers: An IFMA Competency-Based Course*. Houston, Texas: International Facility Management Association (IFMA), 2006.
- Hope, Jeremy, and Steve Player. *Beyond Performance Management*. Boston: Harvard Business Review Press, 2012.
- Horiuchi, Rina, and Ryan Schuchard, BSR; Lucy Shea and Solitaire Townsend, Futerra. “Understanding and Preventing Greenwash: A Business Guide.” BSR (www.bsr.org) and Futerra (www.futerra.co.uk), July 2009.
- Horngren, Charles T., George Foster, and Srikant M. Datar. *Cost Accounting*, 12th edition. Upper Saddle River, New Jersey: Pearson Prentice Hall, 2006.
- “How Much Is Your Daily Indoor Water Use?” U.S. Geological Survey. ga2.er.usgs.gov/edu/sq3action.cfm.
- “How to Conduct Your Own Energy Audit.” Nicor, www.nicor.com/en_us/commercial/planning_needs/build_strategy/energy_audit.htm.
- “How to Conserve Water and Use It Effectively.” U.S. Environmental Protection Agency, www.epa.gov.



- Hua, Ying, Vivian Loftness, Robert Kraut and Kevin M. Powell. "Workplace Collaborative Space Layout Typology and Occupant Perception of Collaborative Environment." *Environment and Planning B: Planning and Design*, Volume 37, 2010.
- "IAQ Building Education and Assessment Model (I-BEAM)." U.S. Environmental Protection Agency, www.epa.gov/iaq/largebldgs/i-beam/index.html.
- ICDRM/GWU *Emergency Management Glossary of Terms*. Institute for Crisis, Disaster, and Risk Management, The George Washington University, February 19, 2007.
- IFMA. "European Benchmarks: Report #2." www.ifma.org/publications/books-reports.
- IFMA. "Space and Project Management Benchmarks Research: Report #28." www.ifma.org/publications/books-reports.
- IFMA FM Consultants Council. "Making a More Effective Business Case to the C-Suite." IFMA Facility Fusion Presentation, April 2012.
- "The Impact of Office Design on Business Performance." Summary of a report by the Commission for Architecture and the Built Environment and the British Council for Offices, May 2005.
- "Improving the Energy Efficiency of Our Buildings." Department for Communities and Local Government (U.K.), January 2008, www.communities.gov.uk/documents/planningandbuilding/pdf/guidancenondwellings.pdf.
- "In Depth Case Studies: Twelve West Indoor Environment." Cascadia Green Building Council, casestudies.cascadiagbc.org/indoorenv.cfm?ProjectID=1725.
- "Indoor Air Pollutants: Exposure and Health Effects." EURO Reports and Studies 78, World Health Organization, 1983.
- "Industry and Market Structure." Naturalgas.org, www.naturalgas.org/business/industry.asp.
- "The Inside Story: A Guide to Indoor Air Quality." U.S. Environmental Protection Agency, www.epa.gov/iaq/pubs/insidest.html.
- "Inside the Googleplex." xfinity.comcast.net/slideshow/finance-insidethegoogleplex/huddlerooms.
- "Integrate Technological Tools." Whole Building Design Guide Productive Committee, 2009, www.wbdg.org/design/integrate_tools.php.
- "Integrated Pest Management In and Around Buildings." Armed Forces Pest Management Board, August 2009, www.afpmb.org/pubs/tims/TG29/tg29.pdf.
- International Association of Emergency Managers. www.iaem.com.
- International Dark-Sky Association, www.darksky.org.



- “International Energy Outlook 2010.” U.S. Energy Information Administration, July 27, 2010, www.eia.doe.gov/oiaf/ieo/.
- International Facility Management Association (IFMA). *FMP Credential Program*. Houston, Texas: International Facility Management Association (IFMA), 2010.
- International Performance Measurement and Verification Protocol*, Volume 1. Washington, D.C.: Efficiency Valuation Organization, September 2009.
- “Intro—What LEED Is.” U.S. Green Building Council (USGBC), www.usgbc.org/DisplayPage.aspx?CMSPageID=1988.
- “Introduction to Energy Performance Contracting.” ICF International and National Association of Energy Services Companies, October 2007, www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf.
- ISO 31000:2009, “Risk Management—Principles and Guidelines.” ISO, 2009, www.iso.org/iso/catalogue_detail?csnumber=43170.
- Jay, Glin W. *Leadership and Management: An IFMA Competency-Based Course*. Houston, Texas: International Facility Management Association (IFMA), 2006.
- Johnson, Gregory P. *ISO 14000 EMS Audit Handbook*. Boca Raton, Florida: CRC Press, 1997.
- Jones Lang LaSalle. *The Little Book of Real Estate Definitions: Asia Pacific*. Singapore: John Wiley and Sons, Inc., 2006.
- Jones Lang LaSalle. “Perspectives on Lease Accounting.” September 2010.
- Kaiser, Harvey H. *The Facilities Audit: A Process for Improving Facilities Conditions*. Alexandria, Virginia: The Association of Higher Education Facilities Officers (APPA), 1993.
- Kangun, Norman, Les Carlson and Stephen J. Grove. “Environmental Advertising Claims: A Preliminary Investigation.” *Journal of Public Policy and Marketing*, 10, 1991.
- Kaplan, Robert S., and David P. Norton. *The Balanced Scorecard: Translating Strategy into Action*. Boston: Harvard Business School Press, 1996.
- Kerzner, Harold. *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, 5th edition. New York: Van Nostrand Reinhold, 1995.
- Kibert, Charles J. *Sustainable Construction: Green Building Design and Delivery*, 2nd edition. New York: Wiley and Sons, 2008.
- Kieso, Donald E., Jerry J. Weygandt and Terry D. Warfield. *Intermediate Accounting*, 10th edition. New York: Wiley, 2001.
- Kincaid, Judith E., Cheryl Walker, and Greg Flynn. *WasteSpec Model Specifications for Construction Waste Reduction, Reuse and Recycling*. Research Triangle Park, North Carolina: Triangle J Council of Governments, 1995.



- “Knowledge- and Technology-Intensive Industries in the World Economy.” Science and Engineering Indicators 2012, National Science Foundation, www.nsf.gov/statistics/seind12/c6/c6s1.htm.
- “Knowledge Translation: A ‘Research Matters’ Toolkit.” publicwebsite.idrc.ca/EN/Resources/Tools_and_Training/Manuals/Research%20that%20Matters%20Knowledge%20Translation%20Toolkit.pdf.
- Knowles, Mike. “Asset Management: Aligning Space Requirements with Action Plans.” *Facility Management Journal*, July/August 2009.
- Koomey, Jonathan G., Christian Belady, Michael Patterson, Anthony Santos and Klaus-Dieter Lange. “White Paper: Assessing Trends Over Time in Performance, Costs and Energy Use for Servers.” *FocusEnergy*, October/November, 2008. www.datacenterdynamics.com.
- Kotter, John P. *Leading Change*. Boston: Harvard Business School Press, 1996.
- Kotter, John P., and James L. Heskett. *Corporate Culture and Performance*. New York: The Free Press, 1992.
- Kubba, Sam. *Property Condition Assessments*. New York: McGraw-Hill, 2008.
- Lanier, Lu Gay, and Neal Beasley. “Recycling Urban Stormwater: 1050 K. NW Street—Washington, D.C.” April-May 2007, Conference Proceedings: Greening Rooftops for Sustainable Communities. Minneapolis, Minnesota.
- Leadership and Strategy Essentials*. Houston, Texas: International Facility Management Association (IFMA), 2010.
- “Leadership, Responsibility, and Growth in Uncertain Times.” Pricewaterhouse Coopers 6th Annual Global CEO Survey, January 2003.
- Leake, Earnie, and John L. Stanley. *Benchmarking for Facility Management Workbook*. Houston, Texas: International Facility Management Association (IFMA), 1994.
- LEED for Existing Buildings: Operations and Maintenance*. Washington, D.C.: U.S. Green Buildings Council, 2008.
- LEED Reference Guide for Green Building Operations and Maintenance*. Washington, D.C.: U.S. Green Buildings Council, 2009.
- Legal HelpMate. “Legal Dictionary and Glossary: Contract Law,” www.legalhelpmate.com/legal-dictionary-result.aspx?legal=Contract-Law.
- “*Legionella* and the Prevention of Legionellosis.” World Health Organization, 2007, www.who.int/water_sanitation_health/emerging/legionella.pdf.
- Lehrer, Jonah. “Groupthink.” *The New Yorker*. January 20, 2012.



- Lewis, Angela. "How to Quantify Building Energy Performance." *FMJ*, September-October 2010.
- Lewis, Angela, and Jim Whittaker. "Identifying and Overcoming Industry Challenges to Reach the BIM FM Vision." *Journal of Building Information Modeling*, Spring 2012.
- Lewis, Angela, Kathleen Cacciola and Robert B. Dennill. *Sustainability in the Food Service Environment*. Sustainability "How-To Guide" Series. Houston, Texas: IFMA Foundation, 2009.
- Lewis, Angela, David Riley and Abbas Elmualim. "Defining High Performance Buildings for Operations and Maintenance." *International Journal of Facility Management*, Vol. 1, No. 2, 2010.
- Lewis, Bernard T., and Richard P. Payant. *The Facility Manager's Emergency Preparedness Handbook*. New York: AMACOM, 2003.
- Lewis, James P. *Fundamentals of Project Management*, 3rd edition. New York: AMACOM, 2007.
- "Life Cycle Costing (LCC) as a Contribution to Sustainable Construction: A Common Methodology." Davis Langdon Management Consulting, May 2007, ec.europa.eu/enterprise/sectors/construction/files/compet/life_cycle_costing/final_rep_summary_en.pdf.
- "Life-Cycle Cost Analysis Primer." Office of Asset Management, U.S. Department of Transportation, August 2002, isddc.dot.gov/OLPFiles/FHWA/010621.pdf.
- "Lighting Answers." Lighting Research Center, February 2007, www.lrc.rpi.edu/programs/nlpi/lightinganswers/lightpollution/cutoffClassifications.asp.
- "Lighting Efficiency Project at Dublin City University." Ciall Energy Saving, 2010, www.dcu.ie/estates.
- Lipp, Doug. *The Changing Face of Today's Customer*. Atlanta: Longstreet Press, 2003.
- Liska, Roger, and Judith Liska. *Building Maintenance: Forms, Checklists and Procedures*. Englewood Cliffs, New Jersey: Prentice Hall, 1998, 2001.
- Lister, Kate, and Tom Hamish. *The State of Telework in the U.S.* Citrix Online and New Ways of Working, June 2011.
- "Local Food." en.wikipedia.org/wiki/Local_food.
- "Long-Range Laser Scanning Helps Replacement of Ice Rink Cooling System." GKS Global Services. March 24, 2010, www.quality digest.com.
- Luginbuhl, Christian B., Constance E. Walker, and Richard J. Wainscoat. "Lighting and Astronomy." *Physics Today*, December 2009, www.darkskiesawareness.org/files/PTarticle_Lighting&Astronomy.pdf.



- Lyll, Angelo. "The Silent Election of Leadership: How Do You Lead?"
www.qualitydigest.com/inside/quality-insider-article/silent-election-leadership.html.
- Magill, Michael K., and Anthony Suruda. "Multiple Chemical Sensitivity Syndrome."
American Family Physician, September 1, 1998, www.aafp.org/afp/980901ap/magill.html.
- Managing Technological Risk*. National Institute of Standards and Technology. April 2000.
- Managing Threats in a Dangerous World*. Chartered Management Institute. March 2011.
- Marques Estrada, Heron. "Cost Dims Future of Solar Energy for Egan Facilities."
Startribune.com, August 14, 2010, www.startribune.com/local/south/100500814.html?page=1&c=y.
- Martin, David M. *The A-Z of Facilities and Property Management*. London: Thorogood Publishing, 2006, 2008.
- Massey, Rachel. "Building a Healthy Economy: Chemicals Risk Management as a Driver of Development." Swedish Chemicals Inspectorate, August 2005, ase.tufts.edu/gdae/Pubs/rp/KemiReport_05.pdf.
- Mathis, Robert L., and John H. Jackson. *Human Resource Management*, 12th edition. Mason, Ohio: South-Western/Thomson Learning, 2008, 2010.
- Mattioli, Dana. "How Going Green Draws Talent, Cuts Costs." *Wall Street Journal*, November 13, 2007, online.wsj.article/SB119492843191791132.html.
- May, Michael, and Geoff Williams, editors. *The Facility Manager's Guide to Information Technology*. Houston, Texas: International Facility Management Association (IFMA), 2012.
- McCarthy, J. F. *Choosing Project Success: A Guide for Building Professionals*. Westchester, Illinois: Pareto—Building Improvement, 2008.
- McDonough, William, and Michael Braungart. *Cradle To Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002.
- McWatters, Cheryl S., Dale C. Morse and Jerold L. Zimmerman. *Management Accounting: Analysis and Interpretation*. Boston: McGraw-Hill Irwin, 2001.
- Melaver, Martin, and Phyllis Mueller, editors. *The Green Building Bottom Line: The Real Cost of Sustainable Building*. New York: McGraw Hill, 2009.
- Mendler, Sandra, et al. *The HOK Guidebook to Sustainable Design*, 2nd edition. New York: Wiley and Sons, 2005.
- Merriam Webster's Collegiate Dictionary*, 10th edition. Springfield, Massachusetts: Merriam-Webster Incorporated, 1994.



- Mills, Evan. *Building Commissioning*. California Energy Commission and Public Interest Energy Research, July 2009.
- Mills, Evan. "Costs and Benefits of Commissioning." Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, 2010, buildings.lbl.gov/comm-perf-costs.html.
- MindTools, www.mindtools.com.
- "Modern Cooling Tower Consideration: Sustainability and Efficiency." *Chem. Insider Daily*, June 7, 2010, www.chem.info/Articles/2010/06/Processing-Equipment-Modern-Cooling-Tower-Considerations-Sustainability-Efficiency/.
- "Money Is Parking Garage Obstacle." *Central Michigan Life*, October 2005, www.cm-life.com/2005/10/10/moneyisparkinggarageobstacle/.
- Monroe, Ian, and Lauren Casey. "U.S. Carbon Markets 101." *Sustainability*, Volume 1, Number 4, August 2008.
- Moser, Cliff, and Carlos Velasquez. "Making Rain from Point Clouds." Presentation at AIA, May 19, 2012.
- Moulton, Pete. *The Telecommunications Survival Guide*. Upper Saddle River, New Jersey: Prentice Hall, 2001.
- Mowen, Maryanne M., and Don R. Hansen. *Management Accounting: The Cornerstone for Business Decisions*. Mason, Ohio: Thomson/South-Western, 2006.
- Munter, Mary. *Guide to Managerial Communication*, 9th edition. Prentice Hall "Guide to Series in Business Communication," 2011.
- Murray, James. "Exclusive: Average Household Paying £30 a Year in Landfill Tax," March 10, 2009, www.businessgreen.com/bg/news/1801361/exclusive-average-household-paying-gbp30-landfill-tax.
- "Musculoskeletal Disorders in Great Britain." *Health and Safety Executive*. www.hse.gov.uk/statistics/causdis/musculoskeletal/index.htm.
- Myers, Kenneth N. *Business Continuity Strategies*, 3rd edition. Hoboken, New Jersey: John Wiley and Sons, 2006.
- "National Pollutant Discharge Elimination System (NPDES)." U.S. Environmental Protection Agency, cfpub.epa.gov/npdes/.
- Naumann, Earl, and Kathleen Giel. *Customer Satisfaction Measurement and Management*. Milwaukee, Wisconsin: ASQ Quality Press, 1995.
- "Noise at Work." *Health and Safety Executive*, www.hse.gov.uk/pubns/omdg362.pdf.



- Nutt, Bev, and Peter McLennan, editors. *Facility Management: Risks and Opportunities*. London: Blackwell Science, 2000.
- “Occupant Indoor Environmental Quality (IEQ) Survey™.” Center for the Built Environment, www.cbe.berkeley.edu/research/survey.htm.
- “Operations and Management Best Practices: A Guide to Achieving Operational Efficiency, Release 2.0.” Federal Energy Management Program, July 2004, eere.pnl.gov/building-technologies/pdf/o_m_guide_2004.pdf.
- Okes, Duke, and Russell T. Westcott, editors. *The Certified Manager of Quality/Organizational Excellence Handbook*, 3rd edition. Milwaukee, Wisconsin: ASQ Quality Press, 2005.
- Olson, Stephen, Jenny Carney and Michael Arny. “Deliver the Green: A Fresh Look at LEED-EB and Facility Management.” Houston, Texas: IFMA Foundation, 2006, leonardoacademy.org/download/Deliver%20the%20Green.pdf.
- O’Reilly, James T., et al. *Keeping Buildings Healthy*. New York: Wiley and Sons, 1998.
- “Osaka Gas: Combined Heat and Power Systems for Large and Small Users.” World Business Council for Sustainable Development, 2008, www.wbcsd.org/DocRoot/WF8l0QIJSHwnSgc5v71s/OsakaGasCHP.pdf.
- “OSHA Technical Manual.” Occupational Safety and Health Administration (U.S.), 1999, www.osha.gov/dts/osta/otm/otm_iii/otm_iii_2.html.
- O’Toole, Daniel. “2009 Integrated Workplace Management Systems Market Perspective and Outlook.” IWMS Connect, media.ifma.org/fmtoday/2009IWMSMarketPerspectiveandOutlook.pdf.
- “Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality.” U.S. Environmental Protection Agency, January 2001, www.epa.gov/smartgrowth/pdf/built.pdf.
- “Our Common Future” (A/RES/42/187). United Nations World Commission on Environment and Development, 1987.
- “An Overview of CASBEE.” Japan Sustainable Building Consortium (JSBC), www.ibec.or.jp/CASBEE/english/overviewE.htm.
- “Parking Spaces/Community Places.” U.S. Environmental Protection Agency, January 2006, www.epa.gov/smartgrowth/pdf/EPAParkingSpaces06.pdf.
- “Pathways to a Low-Carbon Economy.” McKinsey and Company, 2009, www.mckinsey.com/client-service/sustainability/pathways_low_carbon_economy.asp.
- Payant, Richard, and Bernard Lewis. *Facility Manager’s Maintenance Handbook*. New York: McGraw-Hill, 1999, 2007.



- Penny, Janelle. "QR Codes Give Signage Extra Punch." September 9, 2011, www.buildings.com.
- "Performance Contracting." International Institute for Sustainable Development. 2010, www.iisd.org/business/tools/bt_pc.aspx.
- Perlmutter, Howard. "The Tortuous Evolution of Multinational Enterprises." *Columbia Journal of World Business*, 1969.
- "Permeable Surfaces." Florida Field Guide to Low Impact Development, University of Florida Program for Resource Efficient Communities, 2008, buildgreen.ufl.edu/fact_sheet_permeable_surfaces.pdf.
- Peters, Lawrence H., Darrell D. Hartke and John T. Pohlmann. "Fiedler's Contingency Theory of Leadership: An Application of the Meta-Analysis Procedures of Schmidt and Hunter." *Psychological Bulletin*, Volume 97, Issue 2, March 1985.
- Peterson, Kent, and Hugh Crowther. "Building EUIs." *High Performance Buildings*, Summer 2010.
- Peterson, Kristian, and Ross Gammill. *The Economics of Sustainability in Commercial Real Estate*. Houston, Texas: IFMA Foundation, 2009.
- "Photo-Catalytic, Self Cleaning Coating for Building Exteriors." Physorg.com, November 26, 2008, www.physorg.com/news146916753.html.
- Pickering, Peg. *Thriving on Change: Turning Challenge into Success*. Shawnee Mission, Kansas: National Press Publications, 2000.
- Piper, James. "Operable Windows Can Save Energy." December 2008, www.facilitiesnet.com/bom/articlePrint.asp?id=10284.
- Pitt, Robert, Shirley Clark and Keith Parmer. "Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration." U.S. Environmental Protection Agency, May 1994, www.p2pays.org/ref/07/06744.pdf.
- "Pollution Prevention Fact Sheets: Catch Basins." Stormwater Manager's Resource Center, www.stormwatercenter.net/Pollution_Prevention_Factsheets/CatchBasins.htm.
- Porter, Michael E. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: The Free Press, 1980.
- Price Waterhouse Change Integration Team. *Better Change: Best Practices for Transforming Your Organization*. Price Waterhouse, 1996.
- "Pricewaterhouse Coopers 6th Annual Global CEO Survey, Leadership, Responsibility, and Growth in Uncertain Times." Pricewaterhouse Coopers, January 2003, www.pwcglobal.com/gx/eng/ins-sol/surveyrep/ceo6/pwc_6_ceo_survey.pdf.



Principles of Emergency Management Supplement. International Association of Emergency Managers. September 11, 2007, www.iaem.com.

Profiles 2011: Salary and Demographics Report. Research Report #35. Houston, Texas: International Facility Management Association, 2011.

Project Management Institute. *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*, 3rd edition. Newtown Square, Pennsylvania: Project Management Institute, 2004.

Public Service Enterprise Group, www.pseg.com.

“QR Barcode Scanning in Q1-2011.” Mobio Identity Systems, Inc., www.getmobio.com.

“QR Codes.” Kellogg School of Management, March 11, 2011.

“Quality Management Principles,” www.iso.org/iso/qmp.

Recklies, Oliver. “Managing Change—Definition and Phases in Change Processes.” The manager.org, www.themanager.org/strategy/change_phases.htm.

Record Information Services. “Glossary of Legal Terms,” www.public-record.com/content/general/legalterms.asp.

Recruiting and Retaining Qualified Employees—by Design. American Society of Interior Designers, 1999, www.asid.org/NR/rdonlyres/B8A5D323-1379-4332-B0BF-4670BBD3CF6A/0/RecruitingRetaining.pdf.

“Recycling Means Business.” U.S. Environmental Protection Agency, September 1995, www.p2pays.org/ref/02/01888.pdf.

“Reducing Urban Heat Islands: Compendium of Strategies.” U.S. Environmental Protection Agency, www.epa.gov/hiri/resources/pdf/BasicsCompendium.pdf.

Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings. U.S. Federal Emergency Management Agency, Risk Management Series, December 2003.

Renfro, Nancy A., and Joseph L. Smith. *Threat/Vulnerability Assessments and Risk Analysis*. Whole Building Design Guide, October 19, 2011, www.wbdg.org.

ReVelle, Jack B. *Quality Essentials: A Reference Guide from A to Z*. Milwaukee, Wisconsin: ASQ Quality Press, 2004.

Richards, Dick, and Susan Smyth. *Assessing Your Team: Seven Measures of Team Success*. Pfeiffer and Company, 1994.

Richman, Larry. *Improving Your Project Management Skills*. New York: AMACOM, 2006.

A Risk Management Standard. The Institute of Risk Management, 2002, www.theirm.org.



- Roman, Kenneth, and Joel Raphaelson. *Writing That Works*. New York: Harper Resource, 2000.
- Rondeau, Edmond P., Robert Kevin Brown and Paul D. Lapidés. *Facility Management*, 2nd edition. Hoboken: New Jersey: John Wiley and Sons, 2006.
- Roper, Kathy O., Jun Ha Kim and Sang-Hoon Lee. "Strategic Facility Planning: A White Paper on Strategic Facility Planning." Houston, Texas: International Facility Management Association (IFMA), 2009.
- Rosario, Cornel, and Mark Sekula. *The Facility Manager's Field Guide*. CorMark Publishing, LLC, 2011.
- Ryan, Steve. "PC Power Management and the ENERGY STAR Low Carbon IT Campaign." PowerPoint presentation at Commonwealth of Virginia Energy and Sustainability (COVES) conference, September 2008.
- Sammartino, Andre, Janine O'Flynn and Stephen Nicholas. "Managing Diverse Work Teams: A Business Model for Diversity Management." Australian Center for International Business, 2002, www.ecom.unimelb.edu.au.
- Sarkis, Joseph, Laura Meade and Adrien Presley. "Sustainability in the Built Environment: Factors and a Decision Framework." Decision Sciences Institute, www.decisionsciences.org/Proceedings/DSI2008/docs/258-7433.pdf.
- Savitz, Andrew W. *The Triple Bottom Line*. San Francisco: John Wiley and Sons, 2006.
- Scannell, Leila, and Robert Gifford. "Defining Place Attachment: A Tripartite Organizing Framework." *Journal of Environmental Psychology*, 30 (2010).
- Schafer, Rob. "Magic Quadrant for Integrated Workplace Management Systems." Gartner Research. January 31, 2011.
- Schein, Edgar H. *Organizational Culture and Leadership*. San Francisco: John Wiley and Sons, 2004.
- Schermerhorn, John R., et al. *Organizational Behavior*. Hoboken, New Jersey: John Wiley and Sons, 2008, 2010.
- Schmidt, Marty J. *Business Case Essentials: A Guide to Structure and Content*, 3rd edition. Boston: Solution Matrix Ltd., 2009.
- "Science and Engineering Indicators 2012," www.nsf.gov/statistics/seind12/c6/c6s1.htm.
- Seaverson, Eric J. "What Are the Benefits of Vegetative Roofs?" January 2010, www.facilitiesnet.com/roofing/article/What-are-the-Benefits-of-Vegetative-Roofs--11425.
- "Securing Wireless Networks." US-CERT. www.us-cert.gov/cas/tips/ST05-003.html.



- Senge, Peter M., George Roth and Richard B. Ross. *The Dance of Change: The Challenges of Sustaining Momentum in a Learning Organization*. New York: Currency Press, 1999.
- “SFG20—Standard Maintenance Specification for Building Services,” www.sfg20.com.
- Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA). *IAQ Guidelines for Occupied Buildings under Construction*, 2nd edition. Chantilly, Virginia: Sheet Metal and Air Conditioning Contractors’ National Association, 2007.
- Shim, Jae K., Joel G. Siegel and Stephen W. Hartman. *Dictionary of Real Estate*. New York: John Wiley and Sons, Inc., 1996.
- Sisco, Cody, Blythe Chorn and Peder Michael Pruzan-Jorgensen. “Supply Chain Sustainability: A Practical Guide for Continuous Improvement.” UN Global Compact and Business for Social Responsibility, 2010, www.unglobalcompact.org/docs/issues_doc/supply_chain/SupplyChainRep_spread.pdf.
- “The Six Sins of Greenwashing: A Study of Environmental Claims in North American Consumer Markets.” *TerraChoice*, November 2007, www.terrachoice.com/files/6_sins.pdf.
- “The Smart Grid: An Introduction.” U.S. Department of Energy, [www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages\(1\).pdf](http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf).
- Smith, Duke. “An Introduction to Building Information Modeling (BIM).” *Journal of Building Information Modeling*, Fall 2007.
- Snee, Ronald D., and Roger W. Hoerl. *Leading Six Sigma*. Upper Saddle River, New Jersey: Prentice Hall, 2003.
- Society for Human Resource Management (SHRM). *SHRM Learning System*. Alexandria, Virginia: SHRM, 2009.
- “Solar Thermal Case Study.” Southern Energy Management, www.ncpublicpower.com/Libraries/Solar_Energy_Studies/Large_Commercial_Case_Study.sflb.ashx.
- “Space and Project Management Benchmarks.” IFMA Research Report #34. Houston, Texas: International Facility Management Association, 2010.
- “Speech Privacy.” Margenau Associates, Inc., www.margenauassoc.com/index.php/margenau-associates-inc-speech-privacy-systems.html.
- Spiegel, Ross, and Dru Meadows. *Green Building Materials: A Guide to Product Selection and Specification*, 2nd edition. Hoboken, New Jersey: John Wiley and Sons, 2006.
- Srivastara, Samir K. “Green Supply-Chain Management: A State of the Art Literature Review.” *International Journal of Management Reviews*, Vol. 9, No. 1, March 2007.
- “State and Trends of the Carbon Market 2007.” The World Bank, wbcarbonfinance.org/docs/Carbon_Trends_2007-_FINAL_-_May_2.pdf.



- “States with Renewable Portfolio Standards.” U.S. Department of Energy, apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm.
- Stewart, James B. “The Real Heroes Are Dead.” *The New Yorker*, February 11, 2002.
- Stieva, Ginni. “Controlling Energy Demand to Cut Costs.” *Industrial Equipment News*, www.ien.com/article/controlling-energy-demand/7612.
- “Storm Water Technology Fact Sheet: Bioretention.” U.S. Environmental Protection Agency, September 1999, www.epa.gov/owm/mtb/biortn.pdf.
- “Stormwater Management Fact Sheet: Bioretention.” Stormwater Manager’s Resource Center, www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Filte ring%20Practice/Bioretention.htm.
- “Supply Chain Sustainability: A Practical Guide for Continuous Improvement.” United Nations Global Compact, June 2010, www.bsr.org/reports/BSR_UNGC_SupplyChainReport.pdf.
- Survey of Workplace Violence Prevention, 2005*. U.S. Department of Labor, Bureau of Labor Statistics, October 2006.
- “Sustainability Reporting Guidelines, Version 3.0.” Global Reporting Initiative (GRI), 2000-2006, www.globalreporting.org/NR/rdonlyres/A1FB5501-B0DE-4B69-A900-27DD8A4C2839/0/G3_GuidelinesENG.pdf.
- Sustainable Global Leadership Alliance, www.sgla.org.
- Sustainable Sites Initiative. “Guidelines and Performance Benchmarks 2009.” www.sustainablesites.org/report/Guidelines%20and%20Performance%20Benchmarks_2009.pdf.
- “Sustainable Waste Management.” Audit Scotland, 2007, www.audit-scotland.gov.uk/docs/central/2007/nr_070920_waste_management.pdf.
- Tague, Nancy R. *The Quality Toolbox*, 2nd edition. Milwaukee, Wisconsin: ASQ Quality Press, 2005.
- “Target Field Water Recycling Unique.” Kelly Thesier, 2010, mlb.mlb.com/news/article.jsp?ymd=20100112&content_id=7905456&vkey=news_min&fext=.jsp&c_id=min.
- Teicholz, Eric, editor. *Facility Design and Management Handbook*. New York: McGraw-Hill, 2001.
- Teicholz, Eric, editor. *Facility Management Technology*. Houston, Texas: IFMA Foundation, 2012.
- Teicholz, Eric, and Marina Kriticos. *FM Technology Update Part 1: Computer Modeling and Workplace Strategies*. PowerPoint presentation. Houston, Texas: IFMA, 2011.



- “Telework in the European Union.” European Foundation for the Improvement of Living and Working Conditions, 2010, www.slideshare.net/guest499e380/telework-in-the-european-union.
- “Temperature Wars: Savings vs. Comfort.” IFMA, www.ifma.org/tools/research/surveys/HVACSurvey2009.pdf.
- Teplitzky, Alex, and Todd Stoehr. “Underfloor Air Distribution 101.” *Buildings*, January 2009, www.buildings.com/ArticleDetails/tabid/3321/ArticleID/6838/Default.aspx.
- Thayer, Richard H., editor. *Software Engineering Project Management*. Los Alamitos, California: IEEE Computer Society, 1997.
- Theriault, Michel. *Managing Facilities and Real Estate*. Toronto: Woodstone Press, 2010.
- Theriault, Michel. “Sparring Partners.” *Building Operating Management*, May 2010.
- Tieger, Paul D., and Barbara Barron-Tieger. *Do What You Are*. Boston: Little, Brown, and Company, 2001.
- Tierney, John. “From Cubicles, Cry for Quiet Pierces Office Buzz.” *The New York Times*, May 19, 2012.
- “The Tokyo Cap-and-Trade Program—Japan’s First Mandatory Emissions Trading Scheme.” C40 Cities, www.c40cities.org/docs/casestudies/buildings/Tokyo%20Cap%20and%20Trade.pdf.
- Toor, Will. “The Road Less Traveled: Sustainable Transportation for Campuses.” *Planning for Higher Education*, www.secondnature.org/pdf/snwritings/articles/ToorRoad_Less_Traveled.pdf.
- Trusty, Wayne B. “Life Cycle Assessment, Databases and Sustainable Building.” Athena Sustainable Materials Institute, www.athenasmi.org/publications/docs/Ntl_Grn_Bldg_Conf_0406.pdf.
- Tuckman, Bruce W. “Developmental Sequence in Small Groups.” *Psychological Bulletin*, 63(6), 1965.
- Tuckman, Bruce W., and Mary Ann C. Jensen. “Stages of Small-Group Development Revisited.” *Group and Organization Management*, Vol. 2, No. 4, 1977.
- Turner, W. Pitt, IV, John H. Seader, Vince Renaud and Kenneth G. Brill. “Tier Classifications Define Site Structure Performance.” Uptime® Institute White Paper, 2008, www.greenserverroom.org/Tier%20Classifications%20Define%20Site%20Infrastructure.pdf.
- Tuveson, Kit. “Dancing with the Stars: Strategic Facility Management.” IFMA World Work Place Presentation, October 2008.
- “2010 Global Ecolabel Monitor—Towards Transparency.” World Resources Institute, pdf.wri.org/2010_global_ecolabel_monitor.pdf.



- “A Unified Approach for Measuring Office Space for Use in Facility and Property Management.” Building Owners and Managers Association International and International Facility Management Association, 2007.
- “Unitary HVAC Program: Rye Ridge Plaza.” New York State Research and Energy Development Authority, www.nyserda.org/programs/hvac/casestudies/Rye_Ridge_Plaza.pdf.
- United States Department of Justice Antitrust Division. “Price Fixing, Bid Rigging, and Market Allocation Schemes: What They Are and What to Look For.” www.justice.gov/atr/public/guidelines/211578.pdf.
- U.S. Energy Information Administration. *Annual Energy Review 2009*. www.eia.gov/aer/pdf/aer.pdf.
- “Using Virtual Meetings to Improve Communications in Dispersed Organizations.” www.virtualmeeting.com, 2010.
- Valdes, Robert, and David Roos. “How VoIP Works.” computer.howstuffworks.com/ip-telephony5.htm.
- Vallero, Daniel, and Chris Brasier. *Sustainable Design: The Science of Sustainability and Green Engineering*. New York: Wiley and Sons, 2008.
- “The Value of Trees to a Community.” Arbor Day Foundation, www.arborday.org/trees/benefits.cfm.
- Van Horne, James C., and John M. Wachowicz, Jr. *Fundamentals of Financial Management*, 11th edition. Englewood Cliffs, New Jersey: Prentice-Hall Inc., 2004.
- van Ree, Hermen Jan. “FM Benchmarking.” www.dhv.com/dhvcom/files/22/2298d39a-1276-44a1-a598-d66ba2c65a5f.pdf.
- van Ree, Hermen Jan. “The Magnificent Seven.” EFMC European Facility Management Conference 2012 PowerPoint presentation, www.ifma.ch/fileadmin/Vorlagen/International/EFMC/van_Ree__Hermen_Jan.pdf.
- Vavra, Terry G. *Improving Your Measurement of Customer Satisfaction: A Guide to Creating, Conducting, Analyzing, and Reporting Customer Satisfaction Measurement Programs*. Milwaukee, Wisconsin: ASQ Quality Press, 1997.
- “Vending Misers.” Tufts University Office of Sustainability, sustainability.tufts.edu/?pid=39.
- “Ventilation Rates.” www.arca53.dsl.pipex.com/index_files/vent2.htm.
- Von Stein, Edward, and George M. Savage. “Current Practices and Applications in Construction and Demolition Debris Recycling.” *Resource Recycling*, April 1994.
- Voogt, J. A. “Urban Heat Island,” in *Encyclopedia of Global Environmental Change*, Volume 3. New York: Wiley and Sons, 2002.



- Waskom, R., and J. Kallenberger. "Graywater Reuse and Rainwater Harvesting." Colorado State University Extension, July 2009, www.ext.colostate.edu/pubs/natres/06702.html.
- "Waste Reduction." House of Lords, Science and Technology Committee (U.K.), 2008, www.publications.parliament.uk/pa/ld200708/ldselect/ldsctech/163/163.pdf.
- "Wasted Energy: How the U.S. Can Reach its Energy Productivity Potential." McKinsey Global Institute, June 2007, www.compete.org/images/uploads/File/ESIS%20Progressive%20Downloads/McKinsey%20-%20Wasted%20Energy-%20How%20the%20U.S.%20Can%20Reach%20its%20Energy%20Productivity%20Potential.pdf.
- "Water Efficiency Guide: Office and Public Buildings." Department of the Environment and Heritage, (Australia), October 2006, www.environment.gov.au/settlements/publications/government/pubs/water-efficiency-guide.pdf.
- "Water Efficiency Labelling and Standards (WELS) Scheme." www.waterrating.gov.au/watermark.html.
- "Water for Business, Version 2." World Business Council for Sustainable Development, March 2010, www.wbcsd.org/web/water4business.pdf.
- "Water in a Changing World: The United Nations World Water Development Report 3." 2009, United Nations Educational, Scientific and Cultural Organization (UNESCO), www.unesco.org/water/wwap/wwdr/wwdr3/pdf/WWDR3_Water_in_a_Changing_World.pdf.
- "Water Technology—Case Studies." Johnson Controls, www.johnsoncontrols.com/publish/us/en/products/building_efficiency/case_studies2/watersolutions.html.
- Weatherly, Leslie A. "Performance Management Series." Society for Human Resource Management, May 2004. www.shrm.org.
- Wemmers, Rick. "Kick the Bad Players Off the Bus—Now!" *World Workplace*, October 28, 2011.
- Westerkamp, Thomas. *Maintenance Manager's Standard Manual*, 3rd edition. Anaheim, California: BNi Publications, 2007.
- "What Is Biocapacity?" Global Footprint Network, www.footprintnetwork.org/fr/index.php/GFN/page/frequently_asked_technical_questions/#gen3.
- "What Is Green Star?" Green Building Council of Australia, www.gbca.org.au/green-star/green-star-overview.
- White, John J. "The Smart Grid: Intelligent Technology for a Sustainable Future." *Facility Management Journal*, September 2010.
- Whittaker, James P., and Brent Anderson. *Technology Competency Course*. IFMA, 2005.
- "Why Daylight and Views Matter." Haworth, www.haworth.com/en-us/Knowledge/Workplace-Library/Documents/Why-Daylight-and-Views-Matter.pdf.



- Wiggins, Jane M. *Facilities Manager's Desk Reference*. Chichester, United Kingdom: Wiley-Blackwell, 2010.
- Williamson, John. "Business Continuity Planning." July 2002, www.anykeynow.com.
- Witty, Roberta. "Pre-Planning for Plan Invocation." *Continuity*, November/December 2011, www.thebci.org.
- Wood, Brian A., and Marc A. Al. "Sick Building Syndrome: A Potpourri Analysis." *Corporate Counsel Quarterly*, Spring 1999.
- World Wildlife Federation, www.wwf.org.uk.
- "The Worst and Best Woods for Sustainability." Sustainable Floors, www.sustainablefloors.co.uk/the-worst-and-best-woods-for-sustainability.html.
- Wysocki, Robert K., and Rudd McGary. *Effective Project Management: Traditional, Adaptive, Extreme*, 3rd edition. Indianapolis, Indiana: Wiley Publishing, 2003.
- "Xeriscape." Denver Water, www.denverwater.org/Conservation/Xeriscape/.
- Yanarella, Ernest J., and Richard S. Levine. "Don't Pick the Low-Hanging Fruit!" *Sustainability*, Volume 1, Number 4, August 2008, www.liebertonline.com/doi/abs/10.1089/SUS.2008.9945?journalCode=sus.
- Zagreus, Leah, Charlie Huizenga, Edward Arens and David Lehrer. "Listening to Occupants: A Web-Based Indoor Environmental Quality Survey." *Indoor Air*, 2004: 14 (Supplement 8), www.cbe.berkeley.edu/research/pdf_files/Zagreus_2004_InAirSupp.pdf.
- Zechnich, David, and Chris Lee. "Contract Risk and Compliance For All (Economic) Seasons." *Financial Executive*, September 2009, www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/AERS/us_aers_foct_crc_FEIreprint.pdf.
- Zemike, Kate. "The Feng Shui of Schools." *New York Times*, August 5, 2001.
- Zemke, Ron, and John A. Woods, editors. *Best Practices in Customer Service*. Amherst, Massachusetts: HRD Press, 1999.
- Zimmerman, Greg. "Graywater and Water Efficiency." *Building Operating Management*, October 2008, www.facilitiesnet.com/plumbingrestrooms/article/Graywater-and-Water-Efficiency--9839.
- Zimmerman, Mike. "10 Predictions on Commercial Energy Management by 2020." February 15, 2012, www.Greenbiz.com.



Cumulative Course Index

Note: The page numbers used in this index include the number of the book in the Facility Management Learning System, for example, page 2-48 refers to page 48 of Book 2.

A

- ABB (activity-based budgeting), 2-185–2-186
- abbreviations, in business writing, 1-76
- acceptance risk management strategy, 2-285
- access control, and bar codes, 6-82
- accountabilities, clarifying/communicating, 3-239–3-240
 - job design/descriptions, 3-240–3-243
 - level of accountability, 3-240
 - performance evaluations, 3-244–3-245
 - work coordination, 3-243–3-244
- accounting, 2-149
 - accrual basis, 2-149, 2-189
 - cash basis, 2-188
 - cycle, 2-168–2-169
 - double-entry, 2-164–2-167
 - financial, 2-154–2-155
 - in leases, 5-230
 - management, 2-152, 2-154–2-157
 - principles for financial statements, 2-169
 - records, 2-159–2-164
 - single-entry, 2-167
 - standards, 2-157–2-159
- accounts, chart of, 2-149, 2-159–2-162
- accrual basis accounting, 2-149, 2-189
- accumulation, cost, 2-230
- acid-test ratio, 2-235
- acoustical comfort of occupants, 2-105–2-107
- acquisition
 - of space, 4-187–4-189
 - of systems, materials, equipment, 4-44–4-49
 - of team/resources. *See* team/resources, acquiring
- acronyms, in business writing, 1-76–1-77
- Acting phase
 - of strategy life-cycle model, 3-178–3-181
 - of sustainability plan development, 2-26, 2-30–2-31
- active fire protection measures, 4-22
- active listening, 1-27–1-31
- active voice in writing, 1-63–1-64
- activity-based budgeting, 2-185–2-186
- activity-based costing, 2-231, 2-232
- adjacency diagrams, 4-177–4-178, 5-203
- adjourning stage in team life-cycle model, 3-227
- adjustment, as part of preventive maintenance, 4-54
- ADR (alternative dispute resolution), 2-291–2-293
- after-action report, in emergency management, 1-198
- age exploration, 4-59
- age of property development, 5-153–5-154
- AIDC (automatic identification and data capture), 6-80–6-86
- air pollution, and indoor air quality, 2-97
- allocation, cost, 2-231
- alterations
 - clauses in leases, 5-225
 - and occupant services, 4-85–4-86
- alternative dispute resolution, 2-291–2-293
- alternative work strategies, 3-48–3-50
- American National Standards Institute, 5-22–5-23
- American Society for Testing and Materials (ASTM International), 5-23, 5-162, 5-204, 5-241
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 5-23, 5-162
- amortization, 2-149
- Analysis phase
 - of strategy life-cycle model. *See* strategic planning process, developing and implementing
 - of sustainability plan development, 2-26, 2-27–2-29
- annual review of business continuity/emergency preparedness plans, 1-256–1-260
- annual work plan, 2-177–2-180
- annuity, and investment analysis, 5-147
- ANSI (American National Standards Institute), 5-22–5-23
- appearance inspections, 4-71
- appliances
 - energy-efficient, 2-68
 - water-efficient, 2-80
- approvals, and real estate due diligence, 5-213
- arbitration, 2-292
- ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers), 5-23, 5-162
- as-is process maps, 5-121
- assembly areas, in emergency management, 1-202
- assessment centers, 3-98
- asset life-cycle model for total cost of ownership, 3-165
- asset(s), 2-149
 - in balance sheet, 2-197
 - capital, 2-149, 2-181
 - in chart of accounts, 2-160
 - disposal, 4-74–4-75
 - fixed, 2-151



asset(s) (*continued*)
 future purchases, recommending, 4-126
 intangible, 2-152
 life cycle of, 3-165, 4-45–4-46
 liquid, 2-152
 net, in chart of accounts, 2-160
 useful life, 4-116–4-119
 asset management
 and bar codes, 6-81
 and geospatial information systems, 6-78
 and integrated workplace management systems,
 6-56–6-57
 and radio frequency identification, 6-85
 ratios, 2-235–2-236
 assignable area, 4-174, 5-224
 assignment
 cost, 2-231
 as lease exit strategy, 5-232–5-233
 assignments, 3-225
 association, measures of, 5-62–5-63
 ASTM International, 5-23, 5-162, 5-204, 5-241
 audio conferencing, 1-46
 audited financial statements, 2-193–2-194
 auditory learning style, 1-93, 1-94
 audits, 5-8, 5-127–5-130
 of business continuity/emergency preparedness
 plans, 1-256–1-260
 energy, 2-67
 authoritative budget approach, 2-173–2-174
 authority, delegation of, in emergency management,
 1-198
 automated technology, 6-35–6-37. *See also* building
 technology
 automatic identification and data capture, 6-80–6-86
 automation
 and maintenance workflow, 4-66–4-67
 and operation of building systems/equipment, 4-69
 autonomy, 3-242
 average inventory turnover, 2-236
 avoidance risk management strategy, 1-178, 1-186–1-
 187, 2-285
 AWP (annual work plan), 2-177–2-180

B

backward pass scheduling, 4-197
 BACS (building automation and control systems), 2-
 67–2-68, 6-33, 6-37–6-44
 balance sheet, 2-149, 2-197–2-200
 balance, trial, 2-153
 balanced scorecard, 3-148, 3-151–3-154, 3-173–3-
 174, 4-124, 4-282
 outcome measures, 3-152
 performance drivers, 3-152
 perspectives of, 3-153–3-154
 sustainability version of, 2-54–2-55

bandwidth, 6-92
 bankruptcy clauses in leases, 5-223
 bar codes, 6-80–6-83, 6-86
 BARS (behaviorally anchored rating scales), 3-245
 BAS (building automation systems), 2-67–2-68, 6-
 33, 6-37–6-44
 base rent method of service charge allocation, 5-219
 behavior
 employee-centered (consideration), 3-193
 in Hersey-Blanchard situational leadership
 theory, 3-194
 individual, 3-189
 job-oriented (initiating structure), 3-193
 and teams, 3-230–3-232
 behavioral leadership theories, 3-194–3-195
 behavioral/objective methods of performance
 appraisal, 3-113
 behavioral scales, 3-113
 behavioral theories, 3-193, 3-194–3-195
 behaviorally anchored rating scales, 3-245
 benchmarking, 4-208, 5-8
 and business case, 2-215
 competitive, 5-32
 functional, 5-32
 generic, 5-32
 internal, 5-32
 and quality, 5-31–5-38
 and space measurement, 5-204–5-206
 best practices, 3-202, 4-105, 5-8, 5-29
 best value, 2-213
 BIA (business impact analysis), 1-176–1-178
 bid bond, 4-226
 bidding documents, 4-239–4-242
 bilateral contracts, 2-262
 BIM (building information modeling), 6-65–6-72
 biomass systems, 2-70
 Blake-Mouton Managerial Grid, 3-194–3-195
 blanket purchase orders, 2-265
 block diagrams, 5-204
 blocking plans, 5-204
 blogs (Web logs), 1-46, 1-135
 BMS (building management systems), 2-67–2-68, 6-
 33, 6-37–6-44
 BOMA (Building Owners and Managers
 Association), 5-24–5-25, 5-162, 5-204–5-205
 bonds, 4-226–4-227
 book readers, 1-46
 BPA (business process analysis), 1-174–1-176
 BPOs (blanket purchase orders), 2-265
 brainstorming, 3-159, 3-165, 3-229
 “branding,” 3-11–3-12
 BREEAM (Building Research Establishment
 Environmental Assessment Method) certification,
 2-53
 broadband, 6-91



- BRI (building-related illness), 3-27
- British quality standards, 5-23
- BSC. *See* balanced scorecard
- bubble diagrams, 3-164, 4-177–4-178, 5-203–5-204
- budget(s), 2-149
 - capital, 2-149, 2-181–2-182
 - closeout, 2-188–2-189
 - controlling, 4-252–4-253
 - expense projections, 2-183
 - master project, 4-206–4-207
 - monitoring, 2-186–2-188
 - operating, 2-152, 2-176–2-180
 - periods, 2-184
 - in project management plan, 4-205–4-207, 4-215
 - revenue projections, 2-182–2-183
- budget constraint assessments, 3-162
- budgeting, 2-172–2-176, 2-186–2-188
 - activity-based, 2-185–2-186
 - fixed, 2-183–2-184
 - incremental, 2-151, 2-185
 - multinational considerations, 2-189
 - state/cross-border, 2-190
 - variable, 2-183–2-184
 - zero-based, 2-153, 2-185
- building automation and control systems, 2-67–2-68, 6-33, 6-37–6-44
- building automation systems, 2-67–2-68, 6-33, 6-37–6-44
- building certification systems, 2-52–2-54
- building deficiencies in facility condition
 - assessments, 5-177
- building envelope, 2-61, 4-15
- building evaluation, 4-188–4-189
- building imaging, 6-72–6-75
- building information modeling, 6-65–6-72
- building infrastructure, 4-4
- building interiors, and indoor air quality, 2-98, 4-35–4-36
- building management systems, 2-67–2-68, 6-33, 6-37–6-44
- Building Owners and Managers Association
 - standards, 5-24–5-25, 5-162, 5-204–5-205
- building rating systems, 2-52–2-54, 5-26–5-27
- Building Research Establishment Environmental Assessment Method (BREEAM) certification, 2-53
- building structures, 4-11
 - deficiencies in, 4-12, 4-13
 - elements of, 4-11–4-14
 - foundations, 4-13–4-14
 - health/safety considerations, 4-15
- building systems, 4-19–4-20
 - electrical systems, 2-65, 4-27–4-28
 - electronic communications/information technology systems, 4-28–4-29
 - energy use of, 2-62–2-66
 - fire suppression systems, 4-22–4-23
- building systems (*continued*)
 - heating, ventilation and air conditioning systems, 2-63–2-64, 4-25–4-27
 - lighting, 2-64–2-65, 3-28–3-29, 3-32, 4-20
 - plumbing systems, 2-65–2-66, 4-23–4-25
 - safety/security systems, 4-29–4-30
 - transport systems, 2-65, 4-20–4-22
- building technology
 - automatic identification and data capture, 6-80–6-86
 - building automation systems, 2-67–2-68, 6-33, 6-37–6-44
 - building imaging, 6-72–6-75
 - building information modeling, 6-65–6-72
 - energy management systems, 6-44–6-48
 - evolution of, 6-32–6-34
 - geospatial information systems, 6-75–6-80
 - integrated workplace management systems, 6-48–6-60
- See also* automated technology
- building-related illness, 3-27
- built environment, sustainability in, 2-4
- bulleted lists, used in business writing, 1-69–1-70
- business, 2-145, 2-147–2-148
- business cases, 2-210–2-211, 3-180, 4-162, 4-179, 6-118–6-119
 - components of, 2-211–2-212
 - costs/benefits, quantifying, 2-213
 - sample, 2-222–2-226
- business continuity, 1-140, 1-211–1-212, 1-239–1-240, 1-241, 1-255–1-256
 - backup sites, 1-213–1-215
 - benefits of, 1-146–1-147
 - contingency strategies, 1-212–1-216
 - continuity requirements analysis, 1-213
 - data/document continuity, 1-216–1-217
 - evaluation of programs, 1-256–1-260
 - facility manager role, 1-139, 1-144–1-146, 1-242, 1-247–1-248
 - and geospatial information systems, 6-79
 - model, 1-153–1-156
 - planning, 1-140, 1-148, 1-196–1-197, 1-218–1-222
 - purpose of, 1-142–1-143
 - recovery/reconstitution, 1-217, 1-244–1-248
 - and stakeholders, 1-143–1-144
 - strategic alignment of, 1-151–1-152
 - terminology, 1-140
 - training/testing, 1-226–1-236
- See also* risk management
- business impact analysis, 1-176–1-178
- business letters, 1-86–1-88
- business life cycle, 5-138–5-140
- business plans, 1-89–1-91
- business portals, 1-46
- business process analysis, 1-174–1-176
- business unit strategic planning, 3-141–3-142



business writing. *See* writing
 buy/build/expand/renovate analysis, 3-170
 buy-in/approval, in developing strategic facility
 plan/facility master plan, 3-175–3-176

C

campus plans, 3-142
 capacity assessments, 3-162
 capital assets, 2-149, 2-181
 capital budget, 2-149, 2-181–2-182
 capital expenditures, 2-181, 2-216
 capital investments, 2-215
 analysis, 2-217–2-221
 and capital expenditures, 2-216
 and operations expenses, 2-215
 and risk, 2-221–2-222
 and time value of money, 2-216–2-217
 capital plan, 2-208–2-209
 capital, working, 2-153, 2-198
 capitalization
 vs. expense, 2-205
 rates, 5-164–5-165
 carbon footprint, 2-46–2-47
 carbon intensity, 2-47
 carbon trading, 2-75–2-76
 career development, 3-100–3-101
 cartels, 2-271
 CASBEE (Comprehensive Assessment System for
 Built Environment Efficiency) certification, 2-53
 cash basis accounting, 2-188
 cash flow(s), 2-149
 forecasting, 2-206–2-208
 and investment analysis, 5-146
 statement of, 2-153, 2-201–2-202
 category rating methods of performance appraisal, 3-
 112
 cause-and-effect diagrams, 5-39, 5-46–5-47, 5-53
 CEN (European Committee for Standardization), 5-
 24, 5-31, 5-33, 5-35–5-36
 central tendency, measures of, 5-59–5-60
 centralization, 3-219
 certificate of occupancy, 4-274
 chain of command, 1-198, 1-199–1-201, 3-219–3-220
 change, 3-14
 acceptance, stages of, 3-204–3-205
 in facility management contracts, 2-288–2-289
 management, 3-202, 3-203–3-205
 orders, 4-215, 4-219, 4-225, 4-263–4-266
 process, in developing strategic facility
 plan/facility master plan, 3-174–3-175
 resistance to, 1-18, 3-15
 supporting, 3-16–3-18
 chargebacks, 2-149, 2-242–2-244
 charismatic leadership, 3-206
 chart of accounts, 2-149, 2-159–2-162

check sheets, 5-39, 5-45–5-46, 5-53
 check-in, in emergency management, 1-198
 checklist review, of final deliverables, 4-273
 checklists
 in performance assessment/appraisal, 3-112
 quality, 4-208
 churn rate, 3-222
 CI (continuous improvement), 3-202–3-203, 5-8
 circulation factor, 4-174
 cleaning
 and indoor air quality, 2-101–2-102
 noncustodial, 4-54
 cleanliness of workplace, 3-30–3-31, 3-33
 clichés, in business writing, 1-78
 close-ended questions, 1-32, 5-91–5-92
 closeout
 of budgets, 2-188–2-189
 of contracts, 2-280–2-281, 4-275–4-278
 of projects. *See* project closeout
 closing fiscal period, 2-149
 closing projects. *See* project closeout
 cloud computing, 1-46, 6-18–6-19
 CM (construction management) at-risk contracts, 4-222
 CMMS (computerized maintenance management
 systems), 4-52–4-53, 4-67
 CO₂ emissions, measuring, 2-46–2-47
 code compliance
 in leases, 5-223
 and real estate due diligence, 5-213
 Code of Ethics, IFMA, 3-256–3-258
 codes, 4-7–4-8, 4-165–4-166, 5-8, 5-28
 codes of conduct, 3-253–3-254
 enforcement, 3-254
 ethical leadership, 3-255–3-256
 ethics, 3-254–3-255
 IFMA Code of Ethics, 3-256–3-258
 collaborative workplaces, 3-43
 collusion, 2-270
 Color Rendering Index, 2-104
 combined iterative budget approach, 2-173–2-174
 comfort, occupant. *See* occupant comfort; *see also*
 occupant needs
 command
 chain of, in emergency management, 1-198, 1-
 199–1-201
 post, in emergency management, 1-198, 1-201
 unity of, in emergency management, 1-199
 commissioning, 2-66, 4-49–4-50, 4-274
 common area maintenance clauses in leases, 5-223–
 5-224
 common cause variation, 5-8, 5-111
 communication, 1-7–1-10, 1-11–1-12, 3-217
 active listening, 1-27–1-31
 barriers to, 1-17–1-20
 channels, 1-16–1-17



- communication (*continued*)
 - “Cs” of, 1-23
 - and community relations, 1-8
 - cross-cultural, 1-19, 1-33–1-44
 - downward, 1-16–1-17
 - effective, 1-20–1-24
 - efficient, 1-24
 - electronic, 1-44–1-49
 - in emergencies, 1-207–1-210
 - facility management communication plans, 1-126–1-132
 - facility manager role, 1-7, 1-8
 - formal, 1-14
 - forms of, 1-13–1-16
 - “grapevine,” 1-14–1-16
 - informal, 1-14–1-16
 - lateral, 1-16–1-17
 - management, 4-209–4-211, 4-215
 - networks, 3-229–3-230
 - nonverbal, 1-25–1-27
 - and organizational culture, 1-8
 - and organizational structure, 1-8
 - and privacy in workplace, 1-49–1-51
 - process, 1-12–1-13
 - in project execution/control, 4-256–4-258
 - protocols, 1-37
 - questioning, 1-31–1-33
 - redundant systems, 1-209
 - situation-appropriate media, 1-133–1-136
 - stakeholder expectation, 1-125–1-126
 - styles, 1-37
 - technology, 1-8, 6-20, 6-90–6-100
 - and union/work council environment, 1-8
 - upward, 1-16–1-17
 - and vendor/supplier relations, 1-8–1-9
 - See also* business plans; copyright; e-mail; influence; letters; meetings; memos; negotiation; persuasion; presentations; reports; writing
- community relations and communication, 1-8
- comparability, and generally accepted accounting principles, 2-158
- comparative methods of performance appraisal, 3-112
- competency assessments, 3-162
- competition, economic, and technology, 6-12
- competitive benchmarking, 5-32
- complaint management, 5-83–5-85
- compliance, 3-6–3-7
- composting, 2-125
- Comprehensive Assessment System for Built Environment Efficiency (CASBEE) certification, 2-53
- computer avatars, 1-46
- computerized maintenance management systems, 4-52–4-53, 4-67
- condition, and real estate due diligence, 5-213
- conduct, codes of. *See* codes of conduct
- conflict(s)
 - attitudes toward, 1-37
 - constructive vs. dysfunctional, 2-290–2-291, 3-247
 - forwarding, 3-249
 - levels of, 3-248
 - negotiation techniques, 3-248–3-249
 - resolution, 3-245–3-249, 4-261
 - root causes of, 3-246–3-248
 - and situational leadership, 3-248
- conformance standards, 5-21
- consensus standards, 5-21
- consideration (employee-centered behavior), 3-193
- consistency, and generally accepted accounting principles, 2-158
- constraints in projects, 4-163
- construction contract documents, 4-191
- construction drawings, 4-191
- construction management at-risk contracts, 4-222
- construction management contracts, 4-221
- construction, waste reduction in, 2-127–2-129
- constructive vs. dysfunctional conflict, 2-290–2-291, 3-247
- containment, cost, 2-240–2-242
- contaminants and air quality, 4-35–4-36
- contingency strategies, 1-212–1-216
- contingency theories, 3-195–3-196
- contingent equipment, 1-215
- contingent services, 1-215
- contingent workforce, 1-215
- contingent workplaces, 1-213–1-215
- continual improvement. *See* continuous improvement
- continuous commissioning, 2-67, 4-50
- continuous improvement, 3-202–3-203, 5-8, 5-107–5-110
- contract(s), 2-261–2-263
 - administration, 2-273–2-281, 4-261–4-263
 - bilateral, 2-262
 - closeout, 2-280–2-281, 4-275–4-278
 - conflicts, 2-290–2-293
 - construction management (CM) at-risk, 4-222
 - cost reimbursement, 2-265–2-266, 4-220
 - design-bid-build, 4-221
 - design-build, 4-221
 - details of, 4-223–4-229
 - dispute resolution, 2-291–2-293, 4-106–4-108
 - duration, 2-287
 - examining elements of, 2-289–2-290
 - express, 2-262
 - fixed price, 2-265, 2-286–2-287, 4-220
 - fraud in, 2-269–2-273
 - IDQLI (indefinite delivery quantity, line item), 2-266
 - implied, 2-262
 - indefinite delivery quantity, line item, 2-266



contract(s) (*continued*)

- indemnification, 4-229
- insurance coverage, 4-227–4-228
- legal/expert review, 4-225
- licensing, 4-227
- mechanisms, 2-263–2-267
- monitoring, 2-274–2-280
- multiple prime contracts approach, 4-221–4-222
- national buy, 2-266–2-267
- negotiating, 4-244
- nondisclosure agreements, 4-229
- non-typical contractual relationships, 4-228
- non-typical materials/installation methods, 4-229
- not-in-contract items, 4-228
- period of performance, 4-225
- preparation, 4-96–4-97
- project management (PM) at-risk, 4-222
- purchase orders, 2-264–2-265
- renewal options, 2-287
- risk management, 2-281–2-290
- service, 2-275
- service level agreements, 2-277–2-279
- service specifications, 2-275–2-277, 2-278–2-279
- signed, 4-245
- standardized, 4-224–4-225
- terminology, 4-225–4-226
- terms, 2-267–2-269
- time, 4-225
- unenforceable, 2-262
- unilateral, 2-262
- void, 2-262
- voidable, 2-262

contracting, 4-93, 4-94–4-96

- determining activities to contract for, 4-93–4-94
- feedback, 4-105–4-106
- incentives, 4-104

control charts, 5-39, 5-49–5-50, 5-53

control/reduce risk management strategy, 2-285

controlling, 3-187

coordination, and project management, 4-140

copying/printing services, 2-111

copyright, 1-117–1-120

COQ (cost of quality), 4-208

core and service area, 4-173

core and service area factor, 4-174

core building systems. *See* building systems

corporate social responsibility, 3-265–3-269

corrective maintenance, 4-56

correlation, 5-62

cost(s), 2-150, 2-227

- accumulation, 2-230
- allocation, 2-231
- assignment, 2-231
- containment, 2-240–2-242

cost(s) (*continued*)

- controlling, 4-252–4-253
- decision making, use in, 2-231–2-234
- differential, 2-232, 2-234
- direct, 2-229
- drivers, 2-228
- fixed, 2-151, 2-183–2-184, 2-228–2-229
- first, 2-36–2-37
- future, 2-36–2-37
- indirect, 2-229–2-230
- initial, 2-36–2-37
- measurement systems, 2-230–2-231
- mixed, 2-229
- object, 2-228, 2-229–2-230
- opportunity, 2-153, 2-232–2-233, 2-234
- pool, 2-228–2-229
- of quality, 4-208
- relevant range, 2-228
- sunk, 2-233, 2-234
- total, 2-229
- tracing, 2-231
- unit, 2-231
- variable, 2-153, 2-184, 2-227–2-228

cost center, 2-150

cost estimates, in project management plan, 4-204–4-205, 4-215

cost model of service charge allocation, 5-219

cost of operation, 2-150

cost of ownership, 2-150

cost reimbursement contracts, 2-265–2-266, 4-220

cost-benefit analysis, 2-150, 4-208

costing

- activity-based, 2-231, 2-232
- and pricing options in facility management
 - contracts, 2-286–2-287
 - traditional, 2-231, 2-232

CPM (critical path method), 4-200–4-202, 4-203

credit, 2-150

creditor, 2-150

CRI (Color Rendering Index), 2-104

crisis management, 1-148, 1-149

critical assets, 1-171

critical path method, 4-200–4-202, 4-203

critical path scheduling, 4-197

critical processes, 1-172–1-176

cross-border benchmarking/budgeting, 2-190

cross-charging (chargebacks), 2-149, 2-242–2-244

cross-cultural communication, 1-19, 1-33–1-44

cross-functional process maps, 5-122

cross-training, 3-99

CSR (corporate social responsibility), 3-265–3-269

cultural diversity, 1-36–1-39

currency conversion factor, 2-150

currency fluctuations, and real estate, 5-167

current ratio, 2-235



- customer feedback
 - acting on, 5-106–5-112
 - analyzing, 5-101–5-104
 - communicating results, 5-104–5-106
- customer focus, 5-8
- customer needs, and real estate due diligence, 5-211
- customer perspective of balanced scorecard, 3-153–3-154
- customer relationship management, 3-259, 3-260–3-262
- customer satisfaction, 5-8, 5-80, 5-81, 5-83–5-101
- customer segmentation, 5-8
- customer service, 5-9
- customer, voice of, 5-10
- customer-driven FM model, 3-223
- cyclical market conditions, and real estate/property management, 5-154–5-155

D

- damage assessment, 1-242–1-244
- damages, insurance for, 1-243–1-244
- data
 - continuity, 1-216–1-217
 - qualitative, 5-81–5-82
 - quantitative, 5-82
 - reliability of, 5-82–5-83
 - validity of, 5-82–5-83
- data center infrastructure, 6-116–6-118
- data exchange standards, 5-24
- DCF (discounted cash flow analysis), 5-148–5-149
- DCV (demand-controlled ventilation), 2-63, 6-39
- debit, 2-150
- debtor, 2-150
- decentralization, 3-219
- decision-making processes in teams, 3-229
- decline phase in business life cycle, 5-139, 5-140
- decommissioning, 5-236–5-237
- deed, and real estate due diligence, 5-213
- defect repair/validation, 4-273
- degradation curves, 4-116–4-117
- delegation
 - of authority, in emergency management, 1-198
 - in organizational development, 3-201
- deliverables, 4-168
 - accepting, 4-270–4-275
 - checklist review of, 4-273
 - designing, 4-186–4-191
 - in project execution/control, 4-249–4-250
- Delphi technique, 3-229
- demand management, 6-47–6-48
- demand response, 2-73, 6-48
- demand-controlled ventilation, 2-63, 6-39
- Deming, Edwards W., 5-6
- demised property clauses in leases, 5-224
- demographic changes
 - and technology, 6-14
 - and workplace design, 3-44
- deployment charts, 5-44, 5-122
- depreciation, 2-150, 2-203–2-205
- descriptive statistics, 5-59–5-63
- design/engineering construction document/drawings, 4-214
- design/engineering firms, contracting with, 4-189
- design process, 4-190–4-191
- design-bid-build contracts, 4-221
- design-build contracts, 4-221
- detailed flowcharts, 5-44
- dialects, and communication, 1-18
- differential costs, 2-232, 2-234
- digital subscriber line, 6-92
- direct costs, 2-229
- direct negotiation vs. open tender/bidding, 4-237
- disaster recovery planning, 1-140
- disclosure, attitudes toward, 1-37
- discount rate, 2-37–2-38, 2-150, 5-147
- discounted cash flow analysis, 5-148–5-149
- discounted methods of investment analysis, 5-147
- disposal
 - of assets, 4-74–4-75
 - of hazardous materials, 2-135
 - of waste, 2-124–2-125, 4-74–4-75
- dispute resolution, 2-291–2-293, 4-106–4-108
- distractions, as barrier to communication, 1-17
- distributed workspace, 3-48–3-50
- diversification phase in business life cycle, 5-139, 5-140
- diversity, 3-125–3-133
 - aligning policies/practices with, 3-129
 - and compliance with laws/regulations, 3-129
 - cultural, 1-36–1-39
 - generational, 1-18
 - and learning style, 3-125–3-126
 - and recruitment, 3-132
 - and retention, 3-132–3-133
 - and social style, 3-126
 - and training, 3-131–3-132
- divestiture of real estate, 5-209, 5-234–5-237
- DMAIC model, six sigma, 5-56–5-59
- document
 - continuity, 1-216–1-217
 - management, 2-112
- documentation of installed systems, materials, equipment, 4-51–4-53
- double net lease, 5-221
- double-entry accounting, 2-150, 2-164–2-167
- downward communication, 1-16–1-17
- drills, use in training/testing for emergency preparedness/business continuity, 1-231, 1-232, 1-233–1-235
- drive-away kits, and business continuity, 1-220–1-221
- DSL (digital subscriber line), 6-92



due diligence
 for real estate, 5-210–5-214
 for space management, 5-198, 5-199
 duration, and investment analysis, 5-146–5-147
 duty cycling, and building automation systems, 6-39
 dysfunctional vs. constructive conflict, 2-290–2-291, 3-247

E

EAC (equivalent annual cost), 2-151
 earned value analysis, 4-249
 earnings before interest and taxes, 2-150
 earnings before interest, tax, depreciation and amortization, 2-150
 earthworks, 4-37
 EBIT (earnings before interest and taxes), 2-150
 EBITDA (earnings before interest, tax, depreciation and amortization, 2-150
 economic conditions, and real estate due diligence, 5-211
 economic cycle, and real estate/property management, 5-152
 economizers, 2-63
 electrical systems, 2-65, 4-27–4-28
 electronic bulletin boards, 1-46
 electronic communication, 1-44–1-49, 4-28–4-29
 electronic mail (e-mail), 1-46, 1-79–1-84, 1-134
 electronics, energy-efficient, 2-68
 elevators, 2-65, 4-20–4-22
 e-mail, 1-46, 1-79–1-84, 1-134
 emergencies, 1-148–1-151
 escalation, 4-72
 management, 1-140, 1-197–1-202
 operational preparation, 4-71
 planning, 1-140, 4-71–4-72
 emergency assembly area, 1-198
 emergency maintenance, 4-56
 emergency operations center, 1-198
 emergency preparedness, 1-140, 1-148, 1-239–1-240, 1-255–1-256
 benefits of, 1-146–1-147
 evaluation of programs, 1-256–1-260
 facility manager role, 1-139, 1-144–1-146, 1-210–1-211, 1-242, 1-247–1-248
 and geospatial information systems, 6-79
 model, 1-153–1-156
 planning, 1-196–1-197, 1-219–1-222
 purpose of, 1-142–1-143
 recovery/reconstitution, 1-244–1-248
 and stakeholders, 1-143–1-144
 strategic alignment of, 1-151–1-152
 terminology, 1-140
 training/testing, 1-226–1-236
 See also emergency response; risk management
 emergency response, 1-140, 1-148, 1-149, 1-240–1-251
 communications, 1-207–1-210
 damage assessment, 1-242–1-244
 documenting event/response, 1-240–1-241, 1-244
 incident management teams, 1-203–1-204
 and leased facilities, 1-204
 plans, 1-202–1-211
 emphasis, in business writing, 1-73–1-74
 employee/contractor involvement, 3-201
 employee development, 3-77–3-80
 career development, 3-100–3-101
 job requirements, 3-83–3-86
 and organizational needs/values, 3-80–3-83
 performance management, 3-86–3-97
 professional development, 3-98–3-101
 employee needs, and real estate due diligence, 5-211
 employee-centered behavior (consideration), 3-193
 empowerment, 3-201, 3-207
 EMS (energy management systems), 6-44–6-48
 EN 15221, Part 7, “Facility Management,” 5-31, 5-33, 5-35–5-36
 energy, 2-7
 analytics, 6-45–6-46
 audits, 2-67
 consumption, monitoring, 6-39
 demand management, 6-47–6-48
 intensity, 2-47
 managing use, 2-72–2-73, 4-69–4-70
 modeling, 4-118
 monitoring use, 2-72–2-73
 optimizing facility’s use of, 2-66–2-68
 performance contracting, 2-68
 performance statements, 2-51–2-52
 plug-in load, decreasing, 2-68–2-69
 pricing, 2-71–2-72
 renewable sources of, 2-61, 2-69–2-71
 use, 2-60, 2-61–2-69, 2-71–2-77, 4-48
 use intensity, 2-51
 energy management systems, 6-44–6-48
 Energy Performance Certificate, 2-52
 ENERGY STAR Portfolio Manager, 2-47, 2-54
 engineering/design firms, contracting with, 4-189
 entitlements, and real estate due diligence, 5-213
 environment, as barrier to communication, 1-17
 environmental factors, and real estate due diligence, 5-212
 environmental stewardship. *See* sustainability
 EPC (Energy Performance Certificate), 2-52
 EPC (energy performance contracting), 2-68
 equipment, as element in building interiors, 4-33
 equity, 2-151, 2-198
 equivalent annual cost, 2-151
 ergonomics, 3-35, 3-37, 3-38



esteem needs of occupants, 3-11–3-13
 estimation policy, 4-164–4-166
 ethical leadership, 3-255–3-256
 ethics, 3-254–3-255, 3-256–3-258
 ethnocentric management orientation, 1-35
 EUI (energy use intensity), 2-51
 European Committee for Standardization, 5-24, 5-31, 5-33, 5-35–5-36
 executing/controlling projects. *See* project execution/control
 exhaust, and indoor air quality, 2-97
 exit strategies in leasing, 5-231–5-234
 expenditures, capital, 2-181
 expense(s), 2-151
 vs. capitalization, 2-205
 in chart of accounts, 2-161
 fixed, 2-151
 projections of, 2-183
 variable, 2-153
 express contracts, 2-262
 exterior maintenance, 4-37
 exterior structures/elements, 4-15–4-17
 deficiencies in, 4-16–4-17
 health/safety considerations, 4-18–4-19
 roof systems, 4-17–4-18
 signage, 4-18
 external financial statements, 2-193, 2-194
 external promotion of facility management organization, 3-214
 extranets, 1-46
 extrinsic rewards, 3-210–3-211, 3-233

F

facilities audits, 3-148, 3-151
 facilities, monitoring use/performance of, 4-119–4-126
 facilities registers, 3-148, 3-149–3-151
 facility amenities, 2-117
 facility condition assessment, 5-175–5-178
 facility condition index, 5-176–5-177
 facility cost allocation, 5-219–5-220
 facility footprint, reducing, 3-39–3-42
 facility management
 and information technology, 6-25–6-28
 investments, “smoothing,” 2-208–2-09
 from operations and maintenance perspective, 4-4
 organization goals, 3-201–3-205
 facility management communication plans, 1-126–1-132
 Facility Management Learning System, 1-1–1-6
 facility management projects, 4-138, 4-139
 facility managers
 and business continuity, 1-139, 1-144–1-146
 and chargebacks, 2-244
 and communication, 1-7, 1-8
 and emergency preparedness, 1-139, 1-144–1-146, 1-210–1-211, 1-242, 1-247–1-248

facility managers (*continued*)
 and finance/business, 2-145
 and human factors, 3-1–3-3
 and leadership, 3-137, 3-198–3-201
 and operations and maintenance, 4-1, 4-4–4-5
 and project management, 4-133, 4-141, 4-144–4-147
 and quality, 5-1
 and real estate/property management, 5-133–5-136
 and risk management, 1-161–1-162, 1-182, 1-185
 and service specifications/service level agreements, 2-278–2-279, 5-71–5-73
 as strategic partner, 3-196–3-198
 facility master plans, 3-142, 3-177–3-178, 4-160
 buy-in/approval, 3-175–3-176
 change process, 3-174–3-175
 developing (Planning phase of strategy life-cycle model), 3-171–3-178
 formulating strategy, 3-172–3-174
 validating strategy, 3-174
 facility technology plans, 6-9–6-10
 fact sheets, 1-134
 failure modes and effects analysis, 4-59
 fair use, and copyright, 1-119
 falling objects, risk of, 4-19
 falls, risk of, 4-18
 FASB (Financial Accounting Standards Board), 2-151
 FCA (facility condition assessment), 5-175–5-178
 FCA (facility cost allocation), 5-219–5-220
 FCI (facility condition index), 5-176–5-177
 feasibility studies, 2-151, 3-159, 3-168–3-169, 4-160–4-161, 4-169–4-170
 feedback, 3-209–3-210, 3-242
 absence of, as barrier to communication, 1-19
 in communication process, 1-12, 1-22–1-23
 in contracting, 4-105–4-106
 in performance management, 3-97
 360-degree, 3-111
 Feigenbaum, Armand V., 5-6
 Fiedler’s contingency theory, 3-196
 file hosting/sharing, 1-47
 filters in communication process, 1-12
 final inspection/validation, 4-273
 finance, 2-147–2-148
 and real estate due diligence, 5-212
 role of facility managers in, 2-145
 financial accounting, 2-151, 2-154–2-155
 Financial Accounting Standards Board, 2-151
 financial investor requirements, and real estate due diligence, 5-211
 financial leverage, 2-151, 2-198
 financial operations, guidelines for, 2-210
 financial perspective of balanced scorecard, 3-153
 financial plan, 4-160–4-161
 financial ratios, 2-151, 2-234
 asset management ratios, 2-235–2-236
 and facility management metrics, 2-239–2-240



- financial ratios (*continued*)
 - liquidity/short-term debt ratios, 2-234–2-235
 - profitability ratios, 2-236–2-237
 - return-on-investment ratios, 2-237–2-239
 - financial reporting, 2-151
 - financial statements, 2-151, 2-191–2-192, 2-194–2-195
 - accounting principles for, 2-169
 - audited, 2-193–2-194
 - balance sheet, 2-149, 2-197–2-200
 - external, 2-193, 2-194
 - income statement, 2-151, 2-195–2-197
 - internal, 2-192–2-193
 - notes to, 2-202–2-203
 - pro forma statements, 2-153, 2-206–2-209
 - statement of cash flows, 2-153, 2-201–2-202
 - statement of shareholders' equity, 2-153
 - financial terminology, 2-148–2-153
 - financing real estate, 5-164
 - capitalization rates, 5-164–5-165
 - and currency fluctuations, 5-167
 - and interest rate, 5-167
 - mortgage payments, 5-165–5-166
 - sinking funds, 5-166
 - finishes, as element in building interiors, 4-33
 - fire suppression systems, 4-22–4-23
 - first costs, 2-36–2-37
 - fiscal period, closing, 2-149
 - Five Whys, 5-54–5-55
 - fixed assets, 2-151
 - fixed budgeting, 2-183–2-184
 - fixed costs, 2-151, 2-183–2-184, 2-228–2-229
 - fixed expenses, 2-151
 - fixed price (lump sum) contracts, 2-265, 2-286–2-287, 4-220
 - flicker, 2-104
 - floor area measurements, 5-224
 - floor slabs, 4-11
 - flowcharts, 5-39, 5-42–5-45, 5-53
 - flyers, 1-134
 - FMEA (failure modes and effects analysis), 4-59
 - focus groups, in determining customer satisfaction, 5-87–5-88
 - food services
 - sustainable, 2-112–2-113
 - waste reduction in, 2-112, 2-126–2-127
 - forced distribution, 3-112, 3-245
 - forecasting, 4-249
 - cash flows, 2-206–2-208
 - and life-cycle cost, 4-114–4-115
 - space, 5-197–5-198, 5-200–5-201
 - formal communication, 1-14
 - forming stage in team life-cycle model, 3-226
 - forward pass scheduling, 4-197
 - foundations, 4-13–4-14
 - 4G mobile communication system, 6-92
 - frame of reference, and communication, 1-17–1-18
 - fraud/irregularities, in contracts, 2-269–2-273
 - frequency tables, 5-103
 - full service lease, 5-221
 - full-scale exercises, use in training/testing for emergency preparedness/business continuity, 1-230, 1-231, 1-232
 - functional benchmarking, 5-32
 - functional exercises, use in training/testing for emergency preparedness/business continuity, 1-232
 - functional/structural models of FM organization, 3-221
 - functions, 3-217
 - furnishings, as element in building interiors, 4-33
 - future costs, 2-36–2-37
 - future value, 2-216–2-217, 5-145–5-146
 - FV (future value), 2-216–2-217, 5-145–5-146
- ## G
- GAAP (generally accepted accounting principles), 2-151, 2-158–2-159
 - games, use in training/testing for emergency preparedness/business continuity, 1-232
 - Gantt charts, 4-198–4-199
 - gap analysis
 - in developing/implementing strategic planning process, 3-170, 3-171
 - in performance analysis, 5-38–5-39
 - general packet radio service, 6-92
 - general provisions in leases, 5-228–5-230
 - generally accepted accounting principles, 2-151, 2-158–2-159
 - generational diversity, and communication, 1-18
 - generic benchmarking, 5-32
 - geocentric management orientation, 1-35
 - geography and vendor delivery capability, in facility management contracts, 2-286
 - geospatial information systems, 6-75–6-80
 - geothermal systems, 2-70
 - GHG (greenhouse gas) emissions, measuring, 2-46–2-47
 - GIS (geospatial information systems), 6-75–6-80
 - glare, 2-104
 - global meetings, special considerations for, 1-113–1-114
 - Global Reporting Initiative, 2-49–2-50, 3-2
 - globalization, 1-33–1-44, 6-12
 - goals
 - of facility management organization. *See* facility management: organization goals
 - SMART, 2-17–2-18, 3-210
 - stretch, 3-210
 - government regulations, and real estate/property management, 5-161



GPRS (general packet radio service), 6-92
 grade, 4-207
 “grapevine” in communication, 1-14–1-16
 graphic rating scales, 3-112, 3-245
 graywater, 2-80–2-81
 Green Globes, 2-53
 green lease, 5-221
 Green Mark, 2-54
 Green Star, 2-53
 greenhouse gas emissions, measuring, 2-46–2-47
 GRI (Global Reporting Initiative), 2-49–2-50, 3-2
 gross area, 4-173
 gross leasable area, 5-224
 gross lease, 5-221
 gross profit margin, 2-236
 grounds, 4-37–4-38
 hardscape maintenance, 2-113–2-114, 4-39
 landscape maintenance, 2-114–2-117, 4-38–4-39
 safety/security considerations, 4-39–4-40
 group dynamics, 3-228
 Groupe Specific Mobile, 6-92
 growth phase in business life cycle, 5-139
 GSM (Groupe Specific Mobile), 6-92
 guest services, and radio frequency identification, 6-86

H

hardscape maintenance, 2-113–2-114, 4-39
 hazard and operability studies, 4-118
 hazard data sheets, 2-109
 hazardous materials, 2-107–2-108, 4-36–4-37
 disposal of, 2-135
 equipment for, 2-109
 identification of, 2-109
 inspection of storage/handling, 2-135
 minimizing use of, 2-108–2-109
 safety data sheets, 2-109
 storage of, 2-110, 2-135
 training in use of, 2-109
 HAZOP (hazard and operability) studies, 4-118
 HBU (highest and best use), in real estate/property management, 5-155–5-161
 HDS (hazard data sheets), 2-109
 headings/subheadings, used in business writing, 1-69
 health maintenance, 3-36, 3-37
 health/safety
 air quality, 2-98, 4-35–4-36
 and building structures, 4-15, 4-18–4-19
 inspection, 4-70
 and interior furnishings, fixtures, equipment, 4-35–4-37
 heat exchangers, 2-63
 heat island effect, 2-138–2-139
 heating, ventilation and air conditioning systems, 2-63–2-64, 4-25–4-27
 deficiencies in, 4-26–4-27
 demand-controlled ventilation, 2-63

heating, ventilation and air conditioning systems
 (continued)
 economizers, 2-64
 heat exchangers, 2-63
 variable speed drives, 2-63
 Hersey-Blanchard’s situational leadership theory, 3-193–3-194
 Herzberg’s motivation-hygiene theory, 3-191
 highest and best use, in real estate/property management, 5-155–5-161
 histograms, 5-39, 5-50–5-52, 5-53
 human factors
 and effective workplaces, 3-4–3-7
 role of facility manager related to, 3-1–3-3
 humidity, 3-24–3-26, 3-32
 humor, and cross-cultural communication, 1-38
 hygiene factors, 3-191

I

IAQ. *See* indoor air quality
 ice/snow removal, 2-114, 4-72
 ICS (Incident Command System), 1-197–1-198
 ideal process maps, 5-122
 IDQLI (indefinite delivery quantity, line item)
 contracts, 2-266
 IEQ. *See* indoor environmental quality
 IFMA/ASTM standards, 5-162, 5-204
 IFMA/BOMA standards, 5-24–5-25, 5-204
 IFMA Facility Management Learning System, 1-1–1-6
 IFMA standards, 5-24–5-25, 5-162, 5-204
 IFRS (International Financial Reporting Standards), 2-152, 2-157–2-158
 IM (instant messaging), 1-47, 1-135
 implied contracts, 2-262
 improvements clauses in leases, 5-225
 incentives, 4-104
 incident command post, in emergency management, 1-198, 1-201
 Incident Command System, 1-197–1-198
 incident commander, in emergency management, 1-198, 1-200
 incident investigations, 3-65
 incident management teams, 1-203–1-204
 incident response. *See* emergency response
 incineration, 2-125
 income statement, 2-151, 2-195–2-197
 incremental budgeting, 2-151, 2-185
 indefinite delivery quantity, line item contracts, 2-266
 indemnification, 4-229
 index lease, 5-221
 indirect costs, 2-229–2-230
 indirect stakeholders, relationship management, 3-259, 3-264
 individual behavior, 3-189–3-192



- indoor air quality, 2-96–2-98, 3-26–3-27, 3-32
 - and cleaning policy, 2-101–2-102
 - initiatives for, 2-99–2-101
 - and interior furnishings, fixtures, equipment, 4-35–4-36
 - measuring, 2-98–2-99
 - and pest control, 2-102–2-103
 - See also* indoor environmental quality
- indoor environmental quality, 2-7, 2-95–2-96, 3-23–3-24
 - cleanliness, 3-30–3-31, 3-33
 - and hazardous materials, 2-107–2-110
 - humidity, 3-24–3-26, 3-32
 - indoor air quality, 2-96–2-103, 3-26–3-27, 3-32, 4-35–4-36
 - lighting, 2-64–2-65, 3-28–3-29, 3-32
 - noise, 3-29–3-30, 3-33
 - and occupant comfort, 2-103–2-107
 - temperature, 3-24–3-26, 3-32
- influence, 1-115–1-116, 1-117, 3-187, 3-188–3-189
- informal communication, 1-14–1-16
- information technology, 6-25–6-28
- initial costs, 2-36–2-37
- initiating structure (job-oriented behavior), 3-193
- innovation and learning perspective of balanced scorecard, 3-154
- innovation and technology in workplace, 6-104–6-106
- inspections, 5-127–5-130
 - appearance, 4-71
 - final, 4-273
 - of hazardous waste storage/handling, 2-135
 - health/safety, 4-70
 - occasional/periodic, 4-54
 - and upgrading building envelope, 2-62
- inspiration, 3-187
- installation of systems, materials, equipment, 4-49–4-53
- instant messaging, 1-47, 1-135
- insulation, 2-62
- insurance, 2-151, 4-227–4-228
 - for damages, 1-243–1-244
 - in leases, 5-225
- intangible assets, 2-152
- Integrated Services Digital Network, 6-91, 6-92
- integrated workplace management systems, 4-52–4-53, 6-48–6-49, 6-51–6-52, 6-58–6-60
 - and asset management, 6-56–6-57
 - benefits of, 6-52–6-53
 - evolution of, 6-49–6-50
 - and maintenance management, 6-56–6-57
 - and project management, 6-53
 - and real estate management/administration, 6-53–6-54
 - and space management, 6-54–6-56
 - and sustainability, 6-58
- integration
 - of installed systems, materials, equipment, 4-50–4-51
 - and project management, 4-140
- intended use, and real estate/property management, 5-151–5-152
- interest rate, and financing real estate, 5-167
- intergroup dynamics, 3-228–3-229
- interior furnishings, fixtures, equipment, 4-32
 - deficiencies in, 4-34
 - elements of, 4-32–4-34
 - health/safety considerations, 4-35–4-37
- internal benchmarking, 5-32
- internal financial statements, 2-192–2-193
- internal promotion of facility management organization, 3-214
- internal rate of return, 2-152, 2-218–2-221
- internal staff, evaluating for project team, 4-236
- internal stakeholders, relationship management, 3-259, 3-262
- International Financial Reporting Standards, 2-152, 2-157–2-158
- International Organization for Standardization. *See* ISO
- Internet, 6-92
 - forums, 1-47, 1-135
 - technology, 6-91
- interoperability, 6-15–6-17
- interruptions, as barrier to communication, 1-17
- interviews, use in determining customer satisfaction, 5-85–5-87
- intranets, 1-47, 6-92
- intrinsic rewards, 3-210–3-211, 3-233
- inventory management, and bar codes, 6-81
- investment analysis, 5-143–5-144
 - discounted cash flow analysis, 5-148–5-149
 - discounted methods, 5-147
 - nondiscounted methods, 5-147
 - payback period, 5-148
 - risk analysis, 5-149–5-150
- investor requirements, and real estate due diligence, 5-211
- invitation to tender, 2-251–2-252
- IRR (internal rate of return), 2-152, 2-218–2-221
- irregularities/fraud, in contracts, 2-269–2-273
- ISDN (Integrated Services Digital Network), 6-91, 6-92
- Ishikawa, Kaoru, 5-6–5-7
- ISO (International Organization for Standardization), 2-48, 5-9, 5-25–5-26
 - ISO 9000 family of standards, 5-25–5-26
 - ISO 14001, 2-48
 - ISO 15392, 2-48
 - ISO 21930, 2-48
 - ISO 26000, 2-48



IT (information technology), 6-25–6-28
iterative budget approach, 2-173–2-174
iterative project management models, 4-150
ITT (invitation to tender), 2-251–2-252
IWMS. *See* integrated workplace management systems

J

jargon, in business writing, 1-77–1-78
job
 design/descriptions, 3-84–3-86, 3-240–3-243
 enlargement, 3-241
 enrichment, 3-211, 3-241
 requirements, 3-83–3-86
 rotation, 3-99, 3-241
 safety analysis, 4-32
 simplification, 3-241
 title, 3-242–3-243
joint project planning, 4-210
journal(s), 2-152, 2-163–2-164
JPP (joint project planning), 4-210
JSA (job safety analysis), 4-32
Juran, Joseph, 5-6

K

kaizen, 5-109–5-110
key performance indicators, 5-9, 5-74–5-76
kickoff meetings, 4-210, 4-245–4-246
kinesthetic learning style, 1-93, 1-94
knowledge economy, and workplace design, 3-42–3-44
knowledge, skills, abilities (KSAs), 3-242
knowledge workers, 6-12–6-13
KPIs (key performance indicators), 5-9, 5-74–5-76
KSAs (knowledge, skills, abilities), 3-242

L

lagging indicators, 5-65–5-67
LAN (local area network), 6-92
land details, and real estate due diligence, 5-212
landfills, 2-125
landscape maintenance, 2-114–2-117, 4-38–4-39
language, and communication, 1-18, 1-39–1-40
lateral communication, 1-16–1-17
LCC. *See* life-cycle cost/costing
LCCA. *See* life-cycle cost/costing: analysis
leadership, 3-137, 3-138, 3-185–3-189
 role of facility manager, 3-137, 3-198–3-201
 skills, developing, 3-212
 styles, 3-205–3-207, 3-208–3-209
 theories of, 3-192–3-196
leading indicators, 5-65, 5-66–5-67
learning space, 3-42
learning styles, 1-93–1-95, 3-125–3-126
lease abstract, 5-225–5-226

lease audit rights, 5-226
lease buyouts, 5-234
lease or purchase considerations for capital assets, 2-205
leased vs. owned property, 3-221
lease-versus-own analysis, 3-169–3-170
leasing, 2-152, 5-220, 5-215, 5-216
 accounting, 5-230
 exit strategies, 5-231–5-234
 purchase versus lease analysis, 5-217–5-218
 service charge allocations, 5-219–5-220
 space, 4-189
 sustainable policy, 2-19–2-20
 types of, 5-220–5-222
ledgers, 2-152, 2-162–2-163
LEED certification, 2-53
legal constraints, and cross-cultural communication, 1-40–1-41
Legionnaire's disease, 3-27
letters, 1-86–1-88
level of service, 4-79–4-80
liabilities, 2-152
 in balance sheet, 2-198
 in chart of accounts, 2-160
licenses, 2-152, 4-227
life cycle, 2-152
life-cycle cost/costing, 2-152, 2-213–2-215, 4-46–4-47, 4-112–4-119, 5-140–5-143
 analysis, 2-35–2-39, 2-41, 4-112–4-115
 asset life-cycle model, 3-165
 forecasting, 4-114–4-115
 sampling, 4-115
 total cost of ownership, 3-165, 4-112–4-114, 5-141
 and useful life of assets, 4-116–4-119
lifts (elevators), 2-65, 4-20–4-22
light pollution, 2-137
light trespass, 2-137
lighting, 3-28–3-29, 3-32, 4-20
 deficiencies in, 4-20
 guidelines for, 2-105
 improving efficiency of, 2-64–2-65
Likert scale, 5-92–5-93
line vs. staff management, 3-220
liquid assets, 2-152
liquidity/short-term debt ratios, 2-234–2-235
live chats, 1-47
load shedding/shifting, 2-73, 6-47–6-48
local area network (LAN), 6-92
lockdown, in emergency management, 1-198
LOS (level of service), 4-79–4-80
lubrication, as part of preventive maintenance, 4-54
lump sum, and investment analysis, 5-147
lump sum (fixed price) contracts, 2-265, 2-286–2-287, 4-220



M

mail services, 2-110–2-111
 mailing list servers, 1-47
 maintainability
 and acquisition of physical assets, 4-47–4-48
 design for, 4-118
 maintenance, 4-3, 4-53
 activities, 4-57
 corrective, 4-56
 defined, 4-53
 emergency, 4-56
 hardscape, 2-113–2-114, 4-39
 and integrated workplace management systems, 6-56–6-57
 in leases, 5-226
 in peak periods, 4-67–4-68
 planned, 4-7, 4-53, 4-54–4-56
 predictive, 4-53, 4-55–4-56
 preventive, 4-53, 4-54–4-55
 reliability-centered, 4-57–4-60, 4-118
 run-to-failure strategy, 4-56
 total productive, 4-118
 unplanned, 4-7, 4-53, 4-56–4-57
 unscheduled, 4-7, 4-53, 4-56–4-57
 workflow, 4-60–4-67, 4-83–4-84
 major repairs, 4-55
 management, 3-137, 3-185–3-189
 accounting, 2-152, 2-154–2-157
 escalation, and contract dispute resolution, 2-292
 by objectives, 3-113
 orientation, and cross-cultural communication, 1-35–1-36
 styles, 3-207, 3-208–3-209
 Managerial Grid, 3-194–3-195
 market trends, and real estate, 5-154–5-155
 marketing FM organization, 3-212–3-217
 Maslow's needs hierarchy, 3-8, 3-190–3-191
 master project budget, 4-206–4-207
 material handling/storage, 4-72
 material safety data sheets, 2-109, 4-32
 materials and resources, 2-7, 2-82–2-86, 2-134
 matrix models of FM organization, 3-221
 maturity
 phase in business life cycle, 5-139
 task, 3-193–3-194
 MBO (management by objectives), 3-113
 mean, 5-59–5-60
 measures
 of association, 5-62–5-63
 of central tendency, 5-59–5-60
 of variation, 5-60–5-62
 median, 5-59–5-60
 mediation, 2-292
 medium in communication process, 1-12
 meeting services, 2-113

meetings, 1-102–1-114, 1-134
 MEFs (mission-essential functions), 1-172–1-176
 memorandum of understanding, in emergency management, 1-199
 memos, 1-84–1-86
 mentoring, 3-98–3-99
 message in communication process, 1-12
 metrics, 5-9
 micro hydro systems, 2-71
 microprocessor speed/capacity, 6-14
 minor repairs, 4-55
 mission statement, 3-145–3-147
 mission-essential functions, 1-172–1-176
 mitigation risk management strategy, 1-179, 1-187
 mixed costs, 2-229
 mobile devices, 1-134
 mobility of workers, and technology, 6-106–6-108
 mode, 5-59–5-60
 modems, 6-91
 modified gross lease, 5-221
 modified lease, 5-221
 moisture, and indoor air quality, 2-97
 mortgage payments, 5-165–5-166
 motivation, 3-189–3-190
 factors, 3-191
 in teams, 3-233–3-234
 theories of, 3-190–3-192
 motivation-hygiene theory, 3-191
 MOU (memorandum of understanding), in emergency management, 1-199
 move management, 4-86, 6-81–6-82
 MSDS (material safety data sheets), 2-109, 4-32
 multinational FM model, 3-223
 multiple locations, region- or division-led FM model, 3-223
 multiple prime contracts, 4-221–4-222
 Myers-Briggs personality types, 3-191–3-192

N

n (single net) lease, 5-221
 national buy contracts, 2-266–2-267
 natural disasters, and building structures, 4-15
 natural environment, sustainability in, 2-4
 natural light, 2-104–2-105
 nature of work, in facility management contracts, 2-285
 needs assessments, 3-160–3-162, 4-174–4-175, 6-115–6-116
 negotiation, 1-114–1-115, 1-117, 3-248–3-249, 4-97
 of contracts, 4-244
 principled, 3-249
 of service level agreements, 4-97–4-99
 net assets, in chart of accounts, 2-160
 net lease, 5-221
 net net lease, 5-221



net net net lease, 5-221
 net present value, 2-34–2-35, 2-41, 2-152, 2-218–2-221
 net profit margin, 2-237
 network diagrams, 4-200
 new employees, training for, 3-91
 newsletters, 1-135
 NIC (not-in-contract) items, 4-228
 nn (net net) lease, 5-221
 nnn (net net net) lease, 5-221
 “noise” in communication process, 1-12
 noise in workplace, 3-29–3-30, 3-33
 nominal group technique, 3-229
 noncompetitive pricing, 2-270
 noncustodial cleaning, 4-54
 nondisclosure agreements, 4-229
 nondiscounted methods of investment analysis, 5-147
 nonessential functions, 1-173
 nonrenewable resources, 4-49
 non-typical contractual relationships, 4-228
 non-typical materials/installation methods, 4-229
 nonverbal communication, 1-25–1-27, 3-209
 norming stage in team life-cycle model, 3-227
 notes to financial statements, 2-202–2-203
 not-in-contract items, 4-228
 NPV (net present value), 2-34–2-35, 2-41, 2-152, 2-218–2-221

O

O&M. *See* operations and maintenance
 object, cost, 2-228, 2-229–2-230
 observations, 5-99–5-101
 occasional inspection, 4-54
 occupancy, certificate of, 4-274
 occupant behavior, changing, 2-74–2-75
 occupant comfort, 2-103–2-107, 3-7–3-9, 3-22–3-23
 acoustical, 2-105–2-107
 physiological, 3-9–3-10
 thermal, 2-103
 visual, 2-103–2-105
 See also indoor environmental quality; occupant needs/requirements
 occupant needs/requirements, 4-8
 esteem, 3-11–3-13
 safety, 3-10
 self-actualization, 3-13
 social belonging, 3-10–3-11
 See also occupant comfort
 occupant satisfaction, 4-126–4-127
 gathering data on, 2-107, 4-128–4-129
 improvement in, 4-129
 service quotient, 4-127
 occupant services, 4-8, 4-79–4-80
 defined, 4-79
 development of guidelines for, 4-80–4-84
 level of service, 4-79–4-80
 and maintenance workflow, 4-83–4-84

occupant services (*continued*)
 modifications to, 4-84–4-86
 monitoring, 4-100–4-106
 performance measurement, 4-82–4-83
 occupant wellness, 3-33–3-34
 ergonomics, 3-35, 3-37, 3-38
 health maintenance, 3-36, 3-37
 stress, 3-34–3-35, 3-37
 OD (organizational development), 3-200–3-201
 OFCI (owner-furnished, contractor-installed) items, 4-228–4-229
 office manager FM model, 3-223
 off-site training, 3-91–3-92
 OFOI (owner-furnished, owner-installed) items, 4-229
 OJT (on-the-job training), 3-92–3-94
 1D bar codes, 6-81
 one location, multiple sites FM model, 3-223
 one location, one site FM model, 3-223
 one-time purchase orders, 2-264
 one-to-one assignment diagrams, 5-204
 on-the-job training, 3-92–3-94
 open tender/bidding, 4-237–4-238
 open-ended questions, 1-32, 5-91–5-92
 openings, as element in building interiors, 4-33
 operating budget, 2-152
 operating profit margin, 2-237
 operational risk structure, 5-150–5-151
 operations and maintenance, 4-3–4-5
 plan, 4-5–4-8
 role of facility managers, 4-1, 4-4–4-5
 and sustainability, 4-30–4-31
 and workplace safety, 4-31–4-32
 See also maintenance; operations
 operations, 4-3
 and building automation, 4-69
 defined, 4-68
 expenses, 2-215
 systems operation and monitoring, 4-68–4-69
 opportunity costs, 2-153, 2-232–2-233, 2-234
 organizational culture, 3-219
 and communication, 1-8
 and mission/vision statements, 3-145
 organizational design, 3-217
 organizational development, 3-200–3-201
 organizational image, and real estate/property management, 5-138
 organizational needs/values, and employee development, 3-80–3-83
 organizational requirements, and real estate due diligence, 5-211
 organizational structure, 3-217, 3-219
 assessing, 3-218
 centralization/decentralization, 3-219
 chain of command, 3-219–3-220
 churn rate, 3-222
 and communication, 1-8



organizational structure (*continued*)
 FM organization models, 3-222–3-223
 functional/structural models, 3-221
 line vs. staff management, 3-220
 matrix models, 3-221
 owned vs. leased property, 3-221
 relocation, 3-222
 selecting, 3-223–3-224
 span of control, 3-219–3-220
 spatial differentiation, 3-221–3-222
 standardized vs. specialized services, 3-222
 organizational style, in business writing, 1-75
 organizational values, and mission/vision statements, 3-145
 organizing, 3-187
 outcome measures in balanced scorecard, 3-152
 outline formats, 1-66–1-67
 output-based specifications, 2-276, 5-68–5-71
 outsourcing
 as contingency strategy, 1-215–1-216
 and procurement, 2-255–2-258
 owned vs. leased property, 3-221
 owner-furnished, contractor-installed items, 4-228–4-229
 owner-furnished, owner-installed items, 4-229
 ownership documents, and real estate due diligence, 5-213

P

paggers, 1-47
 painting, as part of preventive maintenance, 4-55
 Pareto charts, 5-39, 5-40–5-42, 5-53
 participative budget approach, 2-173–2-174
 parties, in leases, 5-226–5-227
 partner relationship management, 3-259, 3-263–3-264
 parts, replacement of, 4-55
 passive fire protection measures, 4-22
 payback
 with equal annual savings, 2-32–2-33
 period, 2-153, 2-218–2-221, 5-148
 with unequal annual savings, 2-33
 payment bond, 4-227
 payment for work not carried out, 2-271
 PBX (private branch exchange), 6-92
 PDCA model. *See* Plan, Do, Check, Act model
 PdM (predictive maintenance), 4-53, 4-55–4-56
 peak periods, maintenance during, 4-67–4-68
 peer coaches, 3-99
 percentage distribution tables, 5-104
 percentage lease, 5-221
 percentage tables, 5-103
 performance alarms, and building automation systems, 6-39
 performance, and acquisition of physical assets, 4-48

performance assessment/appraisal, 3-95–3-97, 3-107–3-111, 3-244–3-245
 meeting, 3-115–3-118
 methods, 3-111–3-114, 3-244–3-245
 performance bond, 4-226–4-227
 performance data analysis, and building automation systems, 6-39
 performance drivers in balanced scorecard, 3-152
 performance management, 3-86–3-87, 3-118–3-121
 assessment/appraisal of performance, 3-95–3-97, 3-107–3-121
 correction, 3-98
 documenting, 3-87, 3-117–3-118
 expectations, setting, 3-87–3-90
 goals, 3-88–3-90
 rewards, 3-97
 training, 3-90–3-95
 performance measurement, 4-121–4-124
 performance reporting, in project execution/control, 4-256–4-257
 performance-based specifications, 2-276, 5-68–5-71
 performing stage in team life-cycle model, 3-227
 period, in finance/business, 2-153
 periodic inspection, 4-54
 permits needed for projects, 4-165–4-166
 perpetual resources, 4-48
 persuasion, 1-116–1-117
 pest control, and indoor air quality, 2-102–2-103
 photovoltaic systems, 2-69–2-70
 physical condition, and real estate due diligence, 5-213
 physiological comfort of occupants, 3-9–3-10
 PI (profitability index), 2-153
 Plan, Do, Check, Act model, 4-151–4-152, 5-9, 5-55–5-56, 6-115, 6-119–6-126
 planned maintenance, 4-7, 4-53, 4-54–4-56
 planning, 3-187, 4-140
 Planning phase
 of strategy life-cycle model. *See* facility master plans: developing
 of sustainability plan development, 2-26, 2-29–2-30
 plug-in load, decreasing, 2-68–2-69
 plumbing systems, 2-65–2-66, 2-79–2-80, 4-23–4-25
 PM (project management) at-risk contracts, 4-222
 PMBOK (Project Management Body of Knowledge), 4-148–4-149
 PMO (project management office), 4-217
 podcasting, 1-47, 1-134
 POEs (post-occupancy evaluations), 4-281
 policies, 3-234–3-236, 4-72–4-73
 advantages/disadvantages, 3-238–3-239
 audiences, 3-237–3-238
 change process for, 3-239
 evaluation of, 3-239
 implementation and compliance, 3-236–3-237



- policies (*continued*)
 - and project definition, 4-163–4-166
 - sustainability, 2-14–2-21
 - writing, 3-236
- policy deficiencies in facility condition assessments, 5-177
- political correctness in business writing, 1-78–1-79
- pollution, and indoor air quality, 2-97
- polycentric management orientation, 1-35
- portfolio management of real estate, 5-237–5-242
- position power, 3-187–3-188, 3-196
- positive reinforcement, 3-209–3-210
- posters, 1-135
- post-occupancy evaluations, 4-281
- practices, 3-234–3-236, 5-28–5-29
 - advantages/disadvantages, 3-238–3-239
 - audiences, 3-237–3-238
 - change process for, 3-239
 - evaluation of, 3-239
 - implementation and compliance, 3-236–3-237
 - and project definition, 4-163–4-166
 - writing, 3-236
- pre-/post-occupancy surveys, 4-281
- preconstruction meetings, 4-210
- predictive maintenance, 4-53, 4-55–4-56
- premises clauses in leases, 5-227
- prescriptive specifications, 2-276, 5-68–5-71
- present value, 2-38–2-39, 2-153, 2-216–2-217, 5-145–5-146
- presentations, 1-93–1-102, 1-134
- prevention risk management strategy, 1-178–1-179, 1-187
- preventive maintenance, 4-53, 4-54–4-55
- price fixing, 2-270
- pricing
 - and costing options, in facility management contracts, 2-286–2-287
 - noncompetitive, 2-270
- primary circulation, 4-173, 5-224
- printing services, 2-111
- privacy in workplace communication, 1-49–1-51
- private branch exchange, 6-92
- privity of contract/estate, 5-232–5-233
- pro forma statements, 2-153, 2-206–2-209
- probabilistic risk assessment, 4-118
- probing questions, 1-32
- procedures, 3-234–3-236, 4-72–4-73
 - advantages/disadvantages, 3-238–3-239
 - audiences, 3-237–3-238
 - change process for, 3-239
 - evaluation of, 3-239
 - implementation and compliance, 3-236–3-237
 - and project definition, 4-163–4-166
 - writing, 3-236
- process, 5-9
- process improvement, 5-9
- process mapping, 5-9, 5-121–5-124
- process perspective of balanced scorecard, 3-154
- procurement, 2-248–2-249
 - management, 4-219–4-223
 - and outsourcing, 2-255–2-258
 - principles, 2-249–2-250
 - process, 2-251–2-254
 - sustainable, 2-82–2-86, 2-134, 2-250–2-251
- productive workspaces, 2-95
- productivity
 - and geospatial information systems, 6-79
 - in workplace, 5-119–5-120
- professional development, 3-98–3-101
- profitability index, 2-153
- profitability ratios, 2-236–2-237
- programming, 3-159–3-160, 4-171–4-178, 4-190
 - deficiencies in facility condition assessments, 5-177
 - needs assessments, 3-160–3-162, 4-174–4-175
 - needs forecasting, 3-162–3-163
 - requirements analysis and negotiation, 3-163–3-164
 - requirements modeling, 3-164–3-165
 - space programming, 4-172–4-174
 - space standards, 4-172–4-174, 4-178
 - statements of requirements, 4-171, 4-175–4-178
 - strategic vs. full-scale, 3-160
- project charter, 4-178–4-180, 4-214
- project classifications, and investment analysis, 5-146
- project closeout, 4-270–4-275, 4-278–4-280
- project cycles, 4-149–4-150
- project definition, 4-157–4-158
 - aims, 4-168
 - constraints, 4-163
 - deliverables, 4-168
 - documentation, 4-169
 - feasibility study, 4-160–4-161, 4-169–4-170
 - financial plan, 4-160–4-161
 - inputs, 4-158–4-166
 - need(s), 4-168
 - parameters, 4-168–4-169
 - policies, procedures, practices, 4-163–4-166
 - project selection, 4-161–4-162
 - purpose of project, 4-167–4-170
 - requirements, 4-168
 - scope, 4-168
 - specifications, 4-162
 - stakeholders, 4-168
 - statements of work, 4-162
 - strategic plans, 4-159–4-160
 - success criteria, 4-170
- project execution/control, 4-246–4-247
 - communications, 4-256–4-258
 - coordination, 4-248–4-250
 - cost/budget, 4-252–4-253
 - integration, 4-248–4-250



- project execution/control (*continued*)
 - quality assurance/control, 4-254–4-255
 - risk, 4-258–4-260
 - schedule, 4-251–4-252
 - scope, 4-250–4-251
 - project format, 4-153
 - Project Management Body of Knowledge, 4-148–4-149
 - project management plan, 4-214–4-215
 - budget, 4-205–4-207
 - communications management, 4-209–4-211
 - cost estimates, 4-204–4-205
 - and integrated workplace management systems, 6-53
 - project schedule, 4-197–4-203, 4-215
 - quality management, 4-207–4-208
 - risk management, 4-211–4-213
 - technology, 4-249
 - work breakdown structure/task list, 4-194–4-197, 4-214
 - project management, 4-133–4-134, 4-139–4-141, 4-152–4-153
 - at-risk contracts, 4-222
 - vs. FM duties, 4-141
 - office, 4-217
 - processes, 4-148–4-149
 - rationale for use of planning in, 4-134–4-135
 - role of facility manager, 4-133, 4-141, 4-144–4-147
 - See also* project definition; project execution/control; programming; project management plan; project planning
 - project manager, 4-133, 4-141–4-147
 - project objectives statement, 4-178–4-179, 4-180–4-182, 4-214
 - project planning, 4-140, 4-147–4-148
 - creating project management plan, 4-191–4-213
 - designing deliverables/space, 4-186–4-191
 - planning team/resources, 4-213–4-229
 - See also* project management plan
 - project purpose, 4-167–4-170
 - project requirements program, 4-171
 - project resources, 4-166
 - project schedule, 4-197–4-203, 4-215, 4-251–4-252
 - project selection, 4-161–4-162
 - project size, and investment analysis, 5-146
 - project teams
 - evaluating internal staff for, 4-236
 - managing, 4-260–4-261
 - projects, 4-137–4-138. *See also* facility management projects
 - attributes, 4-137–4-138
 - criteria, 4-138
 - reasons for failure, 4-135
 - property loss, 2-153
 - property management, 5-134–5-136. *See also* leasing; real estate
 - property taxes, 2-153
 - proposals, 4-241–4-242
 - protocols, 5-9, 5-30
 - public domain, 1-119–1-120
 - public relations, and marketing facility management organization, 3-214
 - punch list, 4-225, 4-273
 - purchase orders, 2-264–2-265, 4-240
 - purchase versus lease decision, 5-214–5-220
 - purchasing
 - real estate, 5-214, 5-215–5-216
 - space, 4-189
 - PV (present value), 2-38–2-39, 2-153, 2-216–2-217, 5-145–5-146
- ## Q
- qualitative data, 5-81–5-82
 - quality, 4-207, 5-1, 5-4
 - assurance, 4-254–4-255
 - awards, 5-9
 - benchmarking, 5-31–5-38
 - benefits of, 5-1–5-2, 5-3
 - checklists, 4-208
 - control, 4-254–4-255
 - data, 5-30–5-31
 - evolution of, 5-5–5-7
 - gap analysis, 5-38
 - quality control tools, 5-39–5-53
 - quality improvement tools, 5-53–5-59
 - goals, 5-11–5-14
 - management, 4-207–4-208, 4-215, 5-10
 - measures, 5-17–5-21
 - metrics, 4-208
 - role of facility managers in, 5-1
 - of services, 2-7, 2-110–2-117, 4-38–4-39
 - standards, 5-21–5-28
 - statistical analysis, 5-59–5-63
 - quantitative data, 5-82
 - questioning, 1-31–1-33
 - questionnaires/surveys, 5-10, 5-88–5-89, 5-97–5-98
 - design of, 5-90–5-95
 - response rate, 5-95–5-97
 - sampling, 5-89–5-90
 - quick ratio, 2-235
- ## R
- RACI charts, 4-217
 - radio frequency identification, 6-83–6-86
 - rainwater, use of, 2-81
 - range, 5-61
 - ranking, in performance appraisal, 3-112, 3-245
 - rating scales, 3-112, 3-245, 5-92–5-94
 - ratio analysis, 2-234
 - asset management ratios, 2-235–2-236
 - and facility management metrics, 2-239–2-240



- ratio analysis (*continued*)
 - liquidity/short-term debt ratios, 2-234–2-235
 - profitability ratios, 2-236–2-237
 - return-on-investment ratios, 2-237–2-239
- RCA (root cause analysis), 4-59, 5-53–5-54
- RCM (reliability-centered maintenance), 4-57–4-60, 4-118
- readability, in business writing, 1-73
- real estate, 5-134–5-136
 - acquisition, 5-209
 - and age of property development, 5-153–5-154
 - and business life cycle, 5-138–5-140
 - and cyclical market conditions, 5-154–5-155
 - divestiture, 5-209, 5-234–5-237
 - due diligence for, 5-198, 5-199, 5-210–5-214
 - and economic cycle, 5-152
 - facility manager role, 5-133–5-136
 - and financing, 5-164–5-167
 - and government regulations, 5-161
 - and highest and best use, 5-155–5-161
 - and integrated workplace management systems, 6-53–6-54
 - and intended use, 5-151–5-152
 - and investment analysis, 5-143–5-151
 - and life-cycle costing, 5-140–5-143
 - and organizational image, 5-138
 - portfolio management, 5-237–5-242, 6-77–6-78
 - purchase versus lease decision, 5-214–5-220
 - space forecasting, 5-197–5-198, 5-200–5-201
 - space management, 5-194–5-197, 5-198, 5-199
 - space measurement standards/benchmarks, 5-204–5-206
 - space planning, 5-197–5-198, 5-202–5-204
 - space programming, 5-201–5-202
 - space requirements, 5-197–5-198
 - and standards, 5-161–5-163, 5-204–5-206
 - See also* leasing; real estate master plans
- real estate master plans, 3-142, 5-171, 5-172–5-175, 4-160
 - activities in process, 5-188–5-190
 - components, 5-178–5-183
 - and facility condition assessment, 5-175–5-178
 - stakeholders, 5-184–5-188
- real-time system status information, and building automation systems, 6-39
- receiver in communication process, 1-12
- recharging (chargebacks), 2-149, 2-242–2-244
- recommendations and approvals, in developing/implementing strategic planning process, 3-170, 3-171
- recommissioning, 2-66, 4-50
- reconstitution, after emergencies, 1-148, 1-150, 1-217, 1-244–1-248
- recovery, after emergencies, 1-148, 1-150, 1-217, 1-244–1-248
- recruitment and diversity, 3-132
- RECs (renewable energy credits), 2-76
- recycled/recyclable resources, 4-48–4-49
- recycling, 2-125, 2-129–2-135, 4-72
- reduce/control risk management strategy, 2-285
- reducible resources, 4-49
- reducing asset use, as part of replacement, 4-72
- redundant communication systems, 1-209
- reengineering, 3-202, 3-203–3-205
- regiocentric management orientation, 1-35
- regression analysis, 5-63
- regulations
 - and operations and maintenance, 4-7
 - and real estate/property management, 5-161
- regulatory constraints, and cross-cultural communication, 1-40–1-41
- relationship behavior, in Hersey-Blanchard situational leadership theory, 3-194
- relationship management, 3-258–3-260
 - with customers, 3-259, 3-260–3-262
 - with indirect stakeholders, 3-259, 3-264
 - with internal stakeholders, 3-259, 3-262
 - with suppliers/partners, 3-259, 3-263–3-264
- relevance, and generally accepted accounting principles, 2-158
- relevant range, 2-228
- reliability, 5-82–5-83
 - in acquisition of physical assets, 4-47–4-48
 - analysis, 4-59
 - design for, 4-118
 - and generally accepted accounting principles, 2-158
- reliability-centered maintenance, 4-57–4-60, 4-118
- religion, and cross-cultural communication, 1-40
- relocation, 3-222
- remediating performance, 3-96–3-97
- renewable energy credits, 2-76
- renewable resources, 4-48–4-49
- renewable sources of energy, 2-61, 2-69–2-71
- renewal options, in contracts, 2-287
- rent, 5-227
- rentable area, 4-173, 5-224
- rentable/useable ratio, 4-174
- replacement
 - conditions for, 4-73–4-74
 - defined, 4-73
 - of parts, 4-55
- reports, 1-89, 1-92, 3-216
- reputational risk, 2-288
- request for change, 4-264, 4-265
- request for information, 4-240
- request for proposal, 2-251, 4-240–4-241
- request for quotation, 2-252, 4-240
- requirements
 - modeling, 3-164–3-165
 - in project plan, 4-168
- resource recovery, 2-125



resource/service flexibility, in facility management contracts, 2-287

resources. *See also* materials and resources

- acquiring. *See* team/resources, acquiring
- nonrenewable, 4-49
- perpetual, 4-48
- planning. *See* team/resources, planning
- project, 4-166
- recycled/recyclable, 4-48–4-49
- reducible, 4-49
- renewable, 4-48–4-49

response rate in surveys, 5-95–5-97

responsibilities, clarifying/communicating, 3-239–3-240

- job design/descriptions, 3-240–3-243
- level of accountability, 3-240
- performance evaluations, 3-244–3-245
- work coordination, 3-243–3-244

restoration, after emergencies, 1-148, 1-150

retention, and diversity, 3-132–3-133

retrocommissioning, 2-67, 4-50

return on assets, 2-237

return on capital employed, 2-238

return on equity, 2-238

return on investment, 2-33, 2-41, 2-237–2-239

reusing assets, as part of replacement, 4-73

revenue(s), 2-153

- in chart of accounts, 2-160
- projections of, 2-182–2-183

revenue-based lease, 5-221

revising copy, 1-64–1-65

revival phase in business life cycle, 5-139, 5-140

rewards, 3-97, 3-210–3-211, 3-233–3-234

RFC (request for change), 4-264, 4-265

RFI (request for information), 4-240

RFID (radio frequency identification), 6-83–6-86

RFP (request for proposal), 2-251, 4-240–4-241

RFQ (request for quotation), 2-252, 4-240

risk, 1-163–1-164

risk analysis, 5-149–5-150

risk, and capital investments, 2-221–2-222

risk assessment, 1-163, 1-167–1-170, 2-283–2-284

risk categorization, 2-283

risk, controlling, 4-259–4-260

risk, controlling, 4-259–4-260

risk identification, 1-164–1-166, 2-283, 3-61, 3-68, 4-211

risk management, 1-140, 1-148, 1-159–1-160, 1-188–1-191

- acceptance strategy, 2-285
- avoidance strategy, 1-178, 1-186–1-187, 2-285
- business impact analysis, 1-176–1-178
- for contracts, 2-281–2-290
- control/reduce strategy, 2-285
- critical assets, 1-171

risk management (*continued*)

- critical processes, 1-172–1-176
- facility manager role, 1-161–1-162, 1-182, 1-185
- mission-essential functions, 1-172–1-176
- mitigation strategy, 1-179, 1-187
- nonessential functions, 1-173
- prevention strategy, 1-178–1-179, 1-187
- process, 1-162
- programs, 1-181–1-182, 1-183–1-184
- and project planning, 4-211–4-213, 4-215
- risk assessment, 1-163, 1-167–1-170
- risk identification, 1-164–1-166
- supporting functions, 1-172, 1-173
- and technology, 1-185–1-187
- tolerance strategy, 1-178
- transfer/share strategy, 1-180, 1-187, 2-285

risk matrix, 1-168–1-169

risk, monitoring, 4-258–4-259

risk of falling objects, 4-19

risk of falls, 4-18

risk response, 1-178–1-180, 1-186–1-187, 2-284–2-285

risk structure, operational, 5-150–5-151

ROA (return on assets), 2-237

ROCE (return on capital employed), 2-238

ROE (return on equity), 2-238

ROI (return on investment), 2-33, 2-41, 2-237–2-239

roof systems, 4-17–4-18

root cause analysis, 4-59, 5-53–5-54

run charts, 5-63–5-64

run-to-failure strategy, 4-56

S

SaaS (software as a service), 6-19

safety

- and building structures, 4-15
- committees, 3-63–3-64
- evaluation of measures for, 3-66–3-67
- and facility grounds, 4-39–4-40
- incident investigations, 3-65
- as occupant need, 3-10
- and operations and maintenance, 4-31–4-32
- systems, 4-29–4-30
- and third parties, 3-65–3-66
- training, 3-64
- and wireless networks, 6-100
- in workplace, 3-58–3-67

salvage, 4-72

sampling

- and life-cycle cost, 4-115
- in questionnaires/surveys, 5-89–5-90

SCAN (strategic creative analysis), 3-167

scatter diagrams, 5-39, 5-47–5-49, 5-53, 5-104

scenario alternatives, 3-170, 3-171

scenario analysis, 2-221–2-222, 5-150

scenario planning, 3-159, 3-168–3-169



- scheduling, 3-225, 6-39
- schematic design, 4-190
- scope
 - creep, 4-134–4-135
 - in project plan, 4-168
 - of services, 2-285
 - of work, 4-162
- secondary circulation, 4-174, 5-224
- secondary sites, 1-213–1-215
- security
 - deposit, 5-227
 - and facility grounds, 4-39–4-40
 - evaluation of measures for, 3-70–3-71
 - and radio frequency identification, 6-86
 - systems, 4-29–4-30
 - and wireless networks, 6-100
 - in workplace, 3-58–3-60, 3-67–3-71
- self-actualization, as occupant need, 3-13
- seminars, use in training/testing for emergency
 - preparedness/business continuity, 1-230, 1-232
- sender in communication process, 1-12
- sensitivity analysis, 2-221–2-222, 5-150
- SEP (Statement of Energy Performance), 2-52
- sequencing, and building automation systems, 6-39
- service charge allocations, 5-219–5-220
- service contracts, 2-275
- service failure, 288
- service level agreements, 2-277–2-279, 4-90–4-92, 4-97–4-99, 4-101–4-104, 5-10, 5-72–5-73
- service performance assessment, 3-161–3-162, 5-112–5-115
- service providers. *See* contracting
- service quotient, 4-127
- service/resource flexibility, in facility management
 - contracts, 2-287
- service response cards, 5-98–5-99
- service specifications, 2-275–2-277, 2-278–2-279, 5-10, 5-67–5-68
 - drafting, 5-72
 - facility manager role in, 5-71–5-72
 - output-based, 5-68–5-71
 - performance-based, 5-68–5-71
 - prescriptive, 5-68–5-71
- shareholders' equity, statement of, 2-153
- shelter-in-place, 1-199
- Shewhart, Walter, 5-6
- short-term/liquidity ratios, 2-234–2-235
- should-be process maps, 5-121
- sick building syndrome, 3-27
- signage, 4-18
- silence, and cross-cultural communication, 1-38
- simple payback period, 2-32–2-33, 2-41
- single net lease, 5-221
- single-entry accounting, 2-167
- sinking funds, 5-166
- site, 5-194
- site impact, 2-7, 2-136
 - heat island effect, 2-138–2-139
 - light pollution/trespass, 2-137
 - stormwater management, 2-136–2-137
 - and travel, 2-139–2-140
- site search, 4-188
- site selection criteria, 4-188
- situational leadership, 3-193–3-194, 3-205–3-206, 3-248
- situation-appropriate communication media, 1-133–1-136
- six sigma, 5-10, 5-56–5-59
- skill variety, 3-241
- SLAs. *See* service level agreements
- “small talk,” and cross-cultural communication, 1-38
- SMART goals/targets, 2-17–2-18, 4-123–4-124
- SMART test for requirements, 4-177
- “smoothing” facility management investments, 2-208–2-209
- snagging list, 4-225, 4-273
- snow/ice removal, 2-114, 4-72
- social belonging, as occupant need, 3-10–3-11
- social bookmarking, 1-47
- social media/networking, 1-47, 1-135
- social space, 3-42
- social style, 3-126
- software as a service, 6-19
- soil pollutants, and indoor air quality, 2-97
- solar energy systems, 2-69–2-70
- solar gain, decreasing, 2-62
- solar reflectivity index, 2-138, 2-139
- source credibility/status, and communication, 1-18
- SOWs (scope/statements of work), 4-162
- space, 5-194
 - space, acquiring, 4-187–4-189
 - space, designing, 4-186–4-191
 - space forecasting, 5-197–5-198, 5-200–5-201
 - space, leasing, 4-189
 - space management, 5-194–5-197, 5-198, 5-199, 6-54–6-56, 6-105–6-106
 - space measurement standards/benchmarks, 5-204–5-206
 - space needs assessments, 3-162
 - space planning, 5-197–5-198, 5-202–5-204
 - space programming, 4-172–4-174, 5-201–5-202
 - space, purchasing, 4-189
 - space requirements, 5-197–5-198
 - space standards, 4-172–4-174, 4-178
 - span of control, 1-199, 3-219–3-220
 - spatial differentiation, and FM organization, 3-221–3-222
 - SPC (statistical process control), 5-60–5-62
 - special cause variation, 5-10, 5-111–5-112
 - specialized vs. standardized services, 3-222
 - specialties, as element in building interiors, 4-33
 - specifications, 2-275–2-277, 2-278–2-279, 4-162



- SPP (simple payback period), 2-32–2-33, 2-41
- SRI (solar reflectivity index), 2-138, 2-139
- stack plans/diagrams, 5-204
- staff vs. line management, 3-220
- staffing, 3-224
- staging areas, in emergency management, 1-199, 1-201–1-202
- stakeholders
 - and communication, 1-125–1-126, 1-133
 - managing, in project execution/control, 4-257–4-258
 - in project plan, 4-168
 - in sustainability, 2-24–2-26
 - in technology, 6-22–6-28, 6-111
- standard deviation, 5-61–5-62
- standardized contracts, 4-224–4-225
- standardized vs. specialized services, 3-222
- standards, 5-10, 5-27–5-28
 - accounting, 2-157–2-159
 - conformance, 5-21
 - consensus, 5-21
 - in projects, 4-165–4-166
 - quality, 4-208, 5-21–5-28
 - and operations and maintenance, 4-8
 - and real estate/property management, 5-161–5-163
 - space, 4-172–4-174, 4-178
 - space measurement, 5-204–5-206
 - sustainability, 2-48–2-50
- standby power loss, 2-68–2-69
- standing operating order, 4-65
- standing work order, 4-64
- start-up phase in business life cycle, 5-139
- state/cross-border benchmarking/budgeting, 2-190
- statement of cash flows, 2-153, 2-201–2-202
- Statement of Energy Performance, 2-52
- statement of shareholders' equity, 2-153
- statements of requirements, 4-171, 4-175–4-178
- statements of work, 4-162
- statistical process control, 5-60–5-62
- stay/move analysis, 3-170
- step lease, 5-221
- storm preparedness, 4-19
- storming stage in team life-cycle model, 3-227
- stormwater management, 2-136–2-137
- strategic business plan, 3-148–3-149
- strategic creative analysis (SCAN), 3-167
- strategic facility plans, 3-142, 3-176–3-177, 4-159–4-160, 5-172, 5-174, 6-6
 - buy-in/approval, 3-175–3-176
 - change process, 3-174–3-175
 - developing (Planning phase of strategy life-cycle model), 3-171–3-178
 - formulating strategy, 3-172–3-174
 - validating strategy, 3-174
- strategic partner role of facility manager, 3-196–3-198
- strategic planning, 3-140–3-144, 4-159–4-160, 5-171
 - execution, measurement and feedback, 3-143
 - feasibility studies, 3-159, 3-168–3-169
 - gap analysis, 3-170, 3-171
 - scenario alternatives, 3-170, 3-171
 - scenario planning, 3-159, 3-168–3-169
 - statement of requirements, 3-170–3-171
 - and sustainability, 2-21–2-26
 - SWOT (strengths, weaknesses, opportunities, threats) analysis, 3-159, 3-165–3-167
 - tactical planning, 3-143
 - See also* strategic planning process
- strategic planning process, developing and implementing (Analysis phase of strategy life-cycle model), 3-157–3-159, 3-170
 - benchmarking, 3-159
 - brainstorming, 3-159, 3-165
 - feasibility studies, 3-159, 3-168–3-169
 - gap analysis, 3-170, 3-171
 - lease-versus-own variants, 3-159, 3-169–3-170
 - programming, 3-159–3-165
 - recommendations/approvals, 3-170, 3-171
 - scenario alternatives, 3-170, 3-171
 - scenario planning, 3-159, 3-168–3-169
 - statement of requirements, 3-170–3-171
 - SWOT analysis, 3-159, 3-165–3-167
 - See also* strategic planning
- strategic requirements, aligning facility's to entire organization's (Understanding phase of strategy life-cycle model), 3-144–3-145, 3-147–3-148, 3-154–3-157
 - balanced scorecard, 3-151–3-154
 - business unit goals, 3-157
 - client profiles, 3-157
 - comprehensive data for organization, 3-156–3-157
 - defining purpose, success and objectives, 3-155–3-156
 - facilities audits, 3-148, 3-151
 - facilities registers, 3-148, 3-149–3-151
 - gathering data, 3-156
 - mission statement, 3-145–3-147
 - organization culture, 3-145
 - organizational values, 3-145
 - strategic business plan, 3-148–3-149
 - vision statement, 3-145–3-147
- strategy, 3-138, 3-141
 - facility manager's role in, 3-137
 - life-cycle model, 3-143–3-144. *See also* strategic requirements, aligning facility's to entire organization's
 - and technology, 6-6–6-10
 - See also* strategic planning



- streaming media, 1-48, 1-134
- stress, 3-34–3-35, 3-37
- stretch goals, 3-210
- structural/functional models of FM organization, 3-221
- style books, used in business writing, 1-75–1-76
- subcontract requests, 4-241
- subcontracting, 2-285–2-286
- subletting, 5-232–5-233
- substructure, 4-11
- subtask, 4-195
- succession training, 3-94
- sunk costs, 2-233, 2-234
- superstructure, 4-11
- supplier relations and communication, 1-8–1-9
- supplier relationship management, 3-259, 3-263–3-264
- supply chain, 2-85–2-86
- supporting functions, 1-172, 1-173
- surety bond, 4-226–4-227
- surveys/questionnaires, 5-10, 5-88–5-89, 5-97–5-98
 - design of, 5-90–5-95
 - response rate, 5-95–5-97
 - sampling, 5-89–5-90
- sustainability, 2-3–2-5, 2-6
 - and acquisition of physical assets, 4-48–4-49
 - balanced scorecard, 2-54–2-55
 - categories of, 2-6–2-7. *See also* energy; indoor environmental quality; materials and resources; quality of services; site impact; waste; water; workplace management
 - certification, 2-51–2-54, 5-26–5-27
 - and geospatial information systems, 6-78
 - and integrated workplace management systems, 6-58
 - metrics, 2-45–2-47, 2-54–2-55
 - and operations and maintenance, 4-30–4-31
 - plans, 2-21–2-31
 - policies, 2-14–2-21
 - principles, 2-5–2-6
 - projects, 2-31–2-32
 - rankings, 4-48–4-49
 - role of facility managers in, 2-1
 - stakeholders, 2-24–2-26
 - standards, 2-48–2-50
 - and technology, 6-13
 - and Triple Bottom Line, 2-8–2-10
 - vision, 2-14–2-15
- sustainable procurement, 2-82–2-86, 2-134, 2-250–2-251
- swim-lane charts, 5-122
- SWOT (strengths, weaknesses, opportunities, threats) analysis, 3-159, 3-165–3-167
- systems, 4-140, 5-10
- systems operation and monitoring, 4-68–4-69
- systems thinking, 5-10, 5-11–5-14

T

- tabletop exercises, use in training/testing for emergency preparedness/business continuity, 1-230, 1-232
- tactical plans, 3-180–3-181, 3-143, 5-174
 - implementing strategy using (Acting phase of strategy life-cycle model), 3-178–3-181
- tactile learning style, 1-93, 1-94
- task, 4-195
 - behavior, in Hersey-Blanchard situational leadership theory, 3-194
 - identity, 3-241
 - list, 4-194–4-197
 - maturity, 3-193–3-194
 - significance, 3-242
- taxes, property, 2-153
- TCO. *See* total cost of ownership
- TCP/IP (Transmission Control Protocol/Internet Protocol), 6-92
- team/resources, acquiring, 4-233–4-235
 - evaluating internal staff for project team, 4-236
 - selecting staff/contracted resources, 4-242–4-244
 - specifying contracted resource selection process, 4-237–4-238
- team/resources, planning, 4-213–4-214
 - contract details, 4-223–4-229
 - design/engineering construction documents and drawings, 4-214
 - procurement management, 4-219–4-223
 - project charter/project objectives statement, 4-214
 - project management plan, 4-214–4-215
 - project team staff/contractor specifications, 4-216–4-219
- teams, 3-225–3-226
 - behavior theories, 3-230–3-232
 - communication networks, 3-229–3-230
 - decision-making processes, 3-229
 - evaluating, 3-234
 - group dynamics, 3-228
 - inputs, 3-227–3-228
 - intergroup dynamics, 3-228–3-229
 - life-cycle model, 3-226–3-227
 - motivating, 3-233–3-234
 - outputs, 3-230
 - processes, 3-228–3-230
 - rewards, 3-233–3-234
- technical request for proposal, 4-241
- technology, 6-1–6-3, 6-10–6-11, 6-21
 - access, 6-19–6-20
 - automated, 6-35–6-37
 - benefits of, 6-7–6-8
 - building. *See* building technology
 - cloud computing, 1-46, 6-18–6-19
 - communication, 1-8, 6-20, 6-90–6-100



technology (*continued*)

- and competition, 6-12
- and demographic changes, 6-14
- facility technology plans, 6-9–6-10
- and globalization, 6-12
- increase in microprocessor speed/capacity, 6-14
- and innovation, 6-104–6-106
- interoperability, 6-15–6-17
- and knowledge workers, 6-12–6-13
- and mobility of workers, 6-106–6-108
- needs assessment, 6-115–6-116
- optimization process, 6-113–6-114
- projects, 6-111–6-126
- role of facility managers in, 6-1
- risk management for, 1-185–1-187
- software as a service, 6-19
- and space management, 6-105–6-106
- stakeholders, 6-22–6-28, 6-111
- and strategy, 6-6–6-10
- and sustainability, 6-13
- and virtualization, 6-17–6-18
- workplace, 6-104–6-108

telecommuting/telework, 3-49

teleconferencing, 1-48, 1-111, 1-134

temperature, 3-24–3-26, 3-32

tender/bidding, 4-237–4-238

term, in leases, 5-227

termination of leases, 5-233–5-234

text messaging (texting), 1-48, 1-134

Theory X and Y, 3-190

thermal comfort of occupants, 2-103

thermal scanning, 6-74–6-75

thermal systems, 2-69–2-70

thermal treatment of waste, 2-125

third parties, and safety, 3-65–3-66

3D imaging, 6-73–6-74

3G mobile communication system, 6-92

360-degree feedback, 3-111

Three Star System, 2-54

time orientation, and cross-cultural communication, 1-38

time value of money, 2-153, 2-216–2-217, 5-144–5-146

timing, and communication, 1-19

title, and real estate due diligence, 5-213

to-be process maps, 5-121

tolerance risk management strategy, 1-178

top-down flowcharts, 5-44

topic matrix, use in policy development, 2-15

total cost of ownership, 2-39–2-40, 2-41, 3-165, 4-112–4-114, 5-141

total costs, 2-229

total productive maintenance, 4-118

total quality management, 4-208, 5-10

town hall meetings, 1-135

TQM (total quality management), 4-208, 5-10

tracing, cost, 2-231

traditional costing, 2-231, 2-232

training, 3-90–3-91, 3-95

- and diversity, 3-131–3-132
- for leadership skills, 3-212
- for new employees, 3-91
- off-site, 3-91–3-92
- on-the-job, 3-92–3-94
- succession, 3-94

transactional leadership, 3-206

transfer/share risk management strategy, 1-180, 1-187, 2-285

transformational leadership, 3-206

transition, in facility management contracts, 2-288–2-289

Transmission Control Protocol/Internet Protocol (TCP/IP), 6-92

transport systems, 2-65, 4-20–4-22

transportation infrastructure, 4-38

travel, and sustainability, 2-139–2-140

trend, 5-10

trend analysis, 5-10, 5-63–5-67

trial balance, 2-153

Triple Bottom Line, 2-8–2-10

triple net lease, 5-221

Tuckman's team life-cycle model, 3-226–3-227

2D bar codes, 6-81, 6-82–6-83

twisted pair technology, 6-91

U

Understanding phase of strategy life-cycle model. *See* strategic requirements, aligning facility's to entire organization's

Understanding phase of sustainability plan development, 2-26–2-27

undeveloped areas, 4-38

unenforceable contracts, 2-262

unilateral contracts, 2-262

union/work council environment and communication, 1-8

unit costs, 2-231

unity of command, in emergency management, 1-199

unplanned maintenance, 4-7, 4-53, 4-56–4-57

unscheduled maintenance, 4-7, 4-53, 4-56–4-57

upward communication, 1-16–1-17

use and exclusive clauses in leases, 5-228

useable area, 4-173, 5-224

useful life of assets, 4-116–4-119

- data-measuring tools, 4-117–4-118
- degradation curves, 4-116–4-117

utilities, 4-38, 5-228

V

validation, in project closeout, 4-273

validity, 5-82–5-83

value, and real estate due diligence, 5-212



- value judgments, and communication, 1-18
- variable budgeting, 2-183–2-184
- variable costs, 2-153, 2-184, 2-227–2-228
- variable expenses, 2-153
- variable speed drives, 2-63
- variation
 - controlling, 4-215, 5-110–5-112
 - measures of, 5-60–5-62
- vendor
 - conflicts, 2-290–2-293
 - failure, 2-288
 - delivery capability, in facility management contracts, 2-286
 - relations and communication, 1-8–1-9
- ventilation, and indoor air quality, 2-97
- vibration, and comfort of occupants, 2-106–2-107
- videoconferencing, 1-48, 1-111, 1-134
- virtual private network, 6-92
- virtualization, 1-110–1-114, 1-134, 2-94–2-95, 6-17–6-18
- visual comfort of occupants, 2-103–2-105
- visual learning style, 1-93, 1-94
- visuals, used in presentations, 1-98, 1-100
- VOC (voice of the customer), 5-10
- voice of the customer, 5-10
- Voice over Internet Protocol (VoIP), 6-92
- void contracts, 2-262
- voidable contracts, 2-262
- VoIP (Voice over Internet Protocol), 6-92
- VPN (virtual private network), 6-92

W, X, Y, Z

- walk-throughs, 5-99–5-101
- WAN (wide area network), 6-93
- waste, 2-7, 2-124
 - collection, 2-124
 - composting, 2-125
 - disposal, 2-124–2-125, 4-74–4-75
 - hazardous materials, 2-135
 - recycling, 2-125, 2-129–2-135
 - reducing, 2-126–2-129
 - resource recovery, 2-125
 - thermal treatment of, 2-125
- water, 2-7
 - benchmarks for use, 2-78
 - and boiler operation, 2-80
 - landscaping, water-conserving, 2-80
 - pricing, 2-79
 - reducing use of, 2-79–2-80
 - reusing/recycling, 2-80–2-81
 - understanding use of, 2-77–2-79
- waterfall model, 4-149–4-150
- waterway and marine maintenance, 4-38

- WBS (work breakdown structure), 4-194–4-197, 4-214
- WBS dictionary, 4-196–4-197
- Web conferencing, 1-48, 1-111
- Web sites, 1-48, 1-135
- Webcasting, 1-48, 1-134
- Webinars, 1-48, 1-134
- wellness, occupant. *See* occupant wellness
- wetlands, 4-38
- whiteboarding, 1-48
- wide area networks, 6-93
- wikis, 1-48
- wind systems, 2-70–2-71
- wireless access point, 6-93
- wireless local area networks, 6-93
- wireless networks, 6-97–6-100
- wireless technology, 6-91
- WLAN (wireless local area networks), 6-93
- work breakdown structure, 4-194–4-197, 4-214
- work coordination, 3-243–3-244
- work logs, 4-125
- work package, 4-195
- work strategies, alternative, 3-48–3-50
- workflow diagrams, 3-165, 5-44
- workflow, maintenance, 4-60–4-67
- working capital, 2-153, 2-198
- workplace safety. *See* safety
- workplaces, 2-7, 2-92–2-93, 3-39–3-40
 - collaborative, 3-43
 - distributed workspace, 3-48–3-50
 - effective, 3-4–3-7, 3-22–3-23, 3-44–3-47
 - efficient, 3-47–3-48
 - facility footprint, reducing, 3-39–3-42
 - flexible use of space, 2-93–2-94
 - focused, 3-42–3-43
 - healthful, 3-22–3-23. *See also* indoor environmental quality
 - and knowledge economy, 3-42–3-44
 - productivity of, 2-95, 3-22–3-23, 5-119–5-121
 - safe, 3-58–3-67
 - secure, 3-58–3-60, 3-67–3-71
 - virtual, 2-94–2-95
- workshops, use in training/testing for emergency preparedness/business continuity, 1-230, 1-232
- writing, 1-55–1-57
 - content, 1-57–1-65
 - format, 1-69–1-71, 1-73–1-74
 - organization, 1-65–1-69, 1-71–1-73
 - style, 1-75–1-79
 - See also* business plans; e-mail; letters; memos; reports
- zero-based budgeting, 2-153, 2-185

