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Intelligent Infrastructure

How to Make a Smart Building More Profitable

Executive Summary:

The nature of modern buildings is changing dramatically. Buildings once simply provided a space for people to live, learn, and work. Now they have to be smart. Smart buildings are dynamic assets that improve occupant comfort, lower energy costs, and communicate problems. Smart buildings are also expected to work with elements outside their four walls and interact with electrical grids, environmental conditions, and the mission of their organizations.

The recent rush of new technology has accelerated change in how buildings operate, enabling smart buildings to become smarter. But, with a multitude of technology options come new challenges for facility owners and managers. How do you choose among technologies? Will they work together? Bottom line, how do you know if smart building technology is going to provide the energy and cost efficiencies you need?

True smart buildings are more than software analytics and new technologies. Smart buildings start with an intelligent infrastructure. It's an infrastructure defined as one that is based on a robust, open operating system that supports a well-connected and integrated network of building systems and controls. An intelligent infrastructure includes a data analytics platform that turns data into meaningful information. It requires powerful cable networks and an educated service team to support them.

Building an intelligent infrastructure requires a new way of thinking. It looks at your building holistically and applies a technology roadmap that will guide you in supporting its long-term value and efficiency. This paper addresses the components that form an intelligent infrastructure and the need for creating a technology roadmap that prepares you for the future.

"Smart building technology has steadily been increasing its footprint and impact among commercial buildings. Smart building solutions are valuable technologies for deploying energy management strategies that generate operational efficiency, cost containment, and sustainability benefits that appeal to key stakeholders in building management."

IDC, *Business Strategy: Global Smart Building Technology Spending* 2015–2019 Forecast, Doc # EI254932, March 2015

Introduction: The Technology Transformation

The world of buildings is merging with advanced technology faster than ever before. The result is making the long-promised smart building a reality. And, building owners are responding positively. The global smart building market is expected to grow from $5.37 billion to $24.73 billion by the year 2021, according to research published by MarketsandMarkets, a global research and consulting firm. This represents a compound annual growth rate (CAGR) of 34% from 2016 to 2021.

The Internet is enabling this growth. Over the past 10 years, HVAC, lighting, physical security, life safety, and other building systems have tapped into the Building Internet of Things (IoT). As a result, systems can access and share data among themselves and the facility's staff – on-site as well as off–site. Smart data from these systems give a facility's infrastructure a brain and a voice. It allows infrastructure to play a major role in supporting the mission of the organization. It helps drive top-line results by providing optimal environments, increasing equipment uptime and reliability, and lowering operating costs.

As a building's infrastructure becomes increasingly intelligent, it will have a significant impact on the property's long-term value, specifically in how well it can adapt to future systems and requirements. The value of a smart building is very attractive, but there's one catch. Acquiring the technology is relatively easy. Ensuring it delivers on the promised results is the real challenge.

Facility owners, managers and contractors need to look at new building technology holistically. Everything must work together. Ad hoc technology and shortsighted implementation plans can limit efficiency, hamper data collection, and minimize future cost savings. As a result, the expense of the technology may not deliver the promised financial returns.

New Challenges

The introduction of smart building technology is creating new challenges. With an overwhelming amount of technology on the market, understanding its uses, applications, and integration into a holistic system is a full-time job. At the same time, smart building technology needs to interact with information technology (IT) and business systems. Confusion between IT and building technology processes and applications increases as responsibilities cross lines and traditional roles become blurred.

Complicating the discussion is managing building data, otherwise known as big data. Building management systems have always provided meaningful data regarding system use. However, the volume and detail of data coming from smart building technology is unprecedented. Managing it correctly requires new skills.

In his book, *Advanced Technology for Smart Buildings,* James Sinopoli identifies the need for data management planning. He says most building operations do not have a data management plan. Combined with a lack of understanding technology, the lack of data management planning has created significant roadblocks to achieving the cost and performance benefits promised by "smart" building technology.

The Game Has Changed: Addressing

The stakes are high when planning smart building technology for a new facility. The first challenge is making sure the technology is not obsolete by the time the building opens. Most construction projects for modern buildings take three-to-five years from planning to completion. Compare the timing to technology's capacity to double every 18 months. Technology specified in the planning process may be two generations old by the time occupants move in.

Added to the challenge is the fact that an estimated 99% of the various building systems in a construction project are procured separately today. Smart buildings require systems that integrate easily and operate seamlessly as one. With ad hoc systems procured, change orders and RFIs will further slow down the building process and increase costs. Financial losses can mount. Lost are the cost savings gained from buying and installing systems together. In addition, the promised efficiency of the smart building is compromised.

Smart technology poses different challenges for existing buildings. First, your building is occupied and needs to perform well during the planning and implementation processes. Another challenge is the need to preserve your investments in legacy systems. You need to ask how your legacy system will integrate with new technology. How do individual high-tech systems impact the overall efficiency and productivity of a facility? How can facility management be sure the new technology will deliver on its promise? Do you have the skill set in your service team to manage data-driven systems?

There are many questions concerning smart building technology. One thing is clear, simply investing in smart building technology does not create a smart building. Smart buildings, supported by an intelligent infrastructure solution, will reduce costs, enhance productivity, enhance performance, and allow for future adaptability. Getting there requires a new approach to thinking about building systems. It requires a comprehensive plan for all of your systems, technology, and data.

Meeting the Change: Creating an Intelligent Infrastructure

The point of a smart, digital building is to give you valuable information that helps you improve efficiency and reduce short- and long-term costs. For practical purposes, we define smart buildings as those that utilize advanced technology to:

- Improve building performance, including energy, operations, security, and comfort
- Lower the costs of equipment installation, operations, and service
- Generate significantly higher user satisfaction rates

To meet these goals, all smart buildings require an intelligent infrastructure – an infrastructure that allows building systems to converge and integrate seamlessly, acting in unison as one, central nervous system, all the while utilizing advanced analytics to measure, record, and report building system efficiency.

Creating a smart building with an intelligent infrastructure requires a new approach to how we think about building infrastructure. In this new approach, a building's infrastructure is divided into four categories, or types of infrastructure, required for an intelligent infrastructure:

- The planning infrastructure
- The physical infrastructure
- The information infrastructure
- The service infrastructure

The Planning Infrastructure

Creating a smart building with an intelligent infrastructure requires solid planning. There are a variety of different technology systems in an average new building that must interact and communicate with each other. Specifying the right systems is one task. Ensuring they can fully integrate with each other, increase building efficiency, and deliver on the promise of a smart building, is another. You need a holistic view of building technology and systems at the start of the planning process.

To obtain this holistic view, a technology roadmap is essential, whether you're designing new construction or upgrading an existing structure. In new construction, a technology roadmap allows you to take advantage of new technology or innovative building practices. A key advantage is there's no need to make a decision on every technology investment at the moment. However, you do need to identify at what point in the deployment cycle you can make a go/no-go decision on that investment, and still open the facility on time, with the latest technology. It allows you to make future decisions about things that are going to subsequently change, based on the same concept as service planning or obsolescence planning.

For existing buildings, a technology roadmap identifies where you can incorporate legacy systems into the new plan, and what additional investments are needed to maximize past investments. It avoids wasted dollars, poorly integrated systems, and unhappy building users. Most important, it provides your organization a common response toward technology integration and convergence. It empowers your team to work off of the same game plan and use the same language in specifications to reach common results.

Creating a Technology Roadmap
Just as no two buildings are the same, neither are two technology roadmaps. Your plan should have a structure of its own. At its base are your goals and objectives for the building. From there, the roadmap will include:

- A timeline listing the use of and demands on the building for the next 20 years
- A list of building technology requirements including:
  - Major building systems
  - Building subsystems
  - Budget and costs
- A list of information technology (IT) requirements including budget and costs
- Cabling and wiring planning, and budget and costs
- Energy plan, including energy:
  - Demand/use
  - Procurement
  - Utility plans/rebates
  - Alternative and demand/response
- Sustainability requirements including budget and costs
- Integration plan that identifies system synergies, redundancies, and opportunities for future adaptability

The Role of a Technology Consultant
Due to the complexity of the equipment and the roadmap, and to ensure they work together, many owners and managers work with a technology consultant. A technology consultant understands the variety of technology options and which can best meet your facility's goals. More importantly, your technology consultant will be able to advise on how to avoid redundancy and duplication when disparate systems are integrated together.

A technology consultant should be brought into the conversation early in the planning process, during pre-construction, to help create and develop the schematic design for the project. Technology consultants can significantly lower upfront costs and reduce long-term costs. Consulting Specifying Engineer magazine conducted a survey on the impact of collaborative design that includes a technology partner. Nearly 50% of respondents identified that collaborative design reduced the overall project delivery cycle by six months or more, and nearly 60% saw measurable cost savings. A majority of respondents stated that key benefits included:

- Better overall mechanical and electrical design with properly-sized equipment
- Elimination of redundant technologies
- Identification of scope gaps
- Improved system interoperability and integration
- Defined roadmap for technology and communication

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There are many paths to an intelligent infrastructure. Just like following a map to a city center, the route you take depends upon where you are. To know where you are, you will need to start with a technology assessment of your facility. It should include:

- Clear understanding your occupants' business goals
- Development of the building's goals based on the business goals
- Long-term planning and budgeting – including a technology roadmap for 20+ years
- Site pre-planning; environmental design assistance
- Pre-construction and collaboration with construction design team
- Smart/lean construction management options such as IPD
- Technology innovation and ability to leverage Big Data, IoT
- Initiation commissioning and first occupancy
- Service and maintenance skill set
- Perpetual commissioning/FDD/analytics
- De-commissioning/environmental impact – ties back to planning

The Physical Infrastructure

The physical infrastructure of a smart building includes traditional building automation equipment, such as hardware, controllers, cables, and lighting, as well as fire, security, and other systems. It also includes new and developing building systems that meet growing sustainability and efficiency requirements, such as rainwater harvesting, sun-tracking systems, exterior shading, and water reclamation, to name a few.

Smart building infrastructure takes building automation to the next level. It requires an open building management system that offers unlimited integration capabilities, including cloud-based, Internet Protocols (IP). It needs to support analytic tools and platforms, as well as advanced security and fire systems.

A smart building requires an integrated building management system (IBMS). By definition, your IBMS will use open protocols to integrate a large number of software programs and applications. As an open platform, it can connect a wide variety of systems and allow them to "talk" to one another. For example, an IBMS connects lighting control, fire alarms, access control, VMS, and CCTV, energy management, power management, HVAC, automated controls, and anti-intrusion systems. Other components of your IBMS system should include:

- Separate functions for data collection, data normalization, and data correlation
- A rules engine for analysis and workflow creation
- Common user interface for display and controls
- Integration engine middleware
- A robust application engine that allows your facility to utilize web-based architecture for cloud computing, data sharing, business intelligence tools, etc.

An increasingly significant requirement for your IBMS platform is its ability to manage and integrate new and alternative energy sources. A growing number of utilities are offering new options to obtain and manage energy to reduce energy waste and energy costs. Demand-response programs, for example, require that buildings access the local energy grid to buy and sell energy through the grid or through alternative energy sources, such as solar panels or wind turbines.

Other elements of the physical infrastructure include:

- HVAC systems
- Utility systems
- Security systems
- Fire alarm systems
- Lighting systems
- Building system dashboard
- Cabling

Cabling plays a prominent role in an intelligent infrastructure. Smart buildings with intelligent infrastructures require a consistent power supply to manage large amounts of data. End-to-end Ethernet cabling provides power and communications through one cable. While Ethernet use is not necessarily faster than private lines, it increases capacity and is extremely scalable. End-to-end Ethernet can be tied to Internet access, bumping up access speeds appreciably.

Ethernet cables also allow your building an affordable way to connect local area networks (LANs) to a wide area network. Every router has an Ethernet interface. You don't need special hardware, and the technology is very familiar. So, most IT staffers will have little trouble adapting them.

The Information (Data) Infrastructure

Smart buildings collect and communicate unprecedented amounts of data. They require a robust information infrastructure, which is supported by the physical infrastructure. The focus of the information infrastructure is to analyze data and put it to good use – either by generating meaningful reports or communicating instructions to building systems.

The data becomes more than information; it drives action and reaction to ensure safe, secure, and energy-efficient operations. For example, a security system that captures license plate information can be tied to employee databases. When specific employees drive into the parking lot, the building can automatically prepare heating and lighting conditions in their workspaces.

The information infrastructure of a facility consists of four key components:

- IBMS – as discussed in the prior section, your IBMS is the foundation of the physical infrastructure of a smart building. It also acts as the foundation, or nerve center, of your information infrastructure. It is the gateway that connects data analytic software to all building systems and management dashboards.
- Data collection – intelligent field devices record and collect data, feeding the information infrastructure with knowledge. These smart devices enable the Internet of Things for buildings, allowing the building to capture and communicate data. These include smart lighting, air and sound sensors and controls, energy and water meters, video imaging/cameras, and keypads.
- Data analytics – a true analytics platform analyzes data and monitors system performance. It turns knowledge into intelligence, combining energy information with performance of other building systems to improve building productivity as a whole. In short, it provides transparency within your building and its multiple systems. With a powerful analytic platform, you can collect and analyze data from every facility in your portfolio to provide one, comprehensive view of your portfolio's performance and what's needed to improve.
- Fault Detection and Diagnostics (FDD) – FDD is a technology that is often part of a data analytics platform. It collects data and identifies faults, or errors, based on established hierarchical relationships and rules between the different equipment and processes.

Your information infrastructure allows you to apply data to your building system to maximize results. Integrating data analytics with your IBMS allows you to measure energy and efficiency performance at all levels of your organization, generating tailored reports for your facility, such as:

- Energy analysis:
  - Benchmarks key performance indicators
  - Analyzes your building's, or enterprise's, entire portfolio
  - Identifies cost-saving billing errors from energy suppliers
  - Improves budget performance by comparing energy budgets, prices, actual costs, and hedging positions
  - Provides ENERGY STAR® benchmarking of your portfolio

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A hospital in Florida recently incorporated FDD into its system. It uncovered nearly 1,000 faults. However, it was able to analyze them and prioritize which needed to be addressed immediately and which could be addressed at a later date. They discovered that numerous air handling units weren't operating properly, and remained closed or partially closed when they needed to be open. The cooling system was increasing levels of cool air to compensate and ensure the rooms maintained optimal temperature. Cost for the additional cooling levels were estimated to be more than $10,000 a year. Repair and replacement of the faulty air ducts resulted in immediate, documented savings.

- System performance:
  - Allows access to a holistic view of your infrastructure's performance
  - Offers clear insight for improving operational efficiency
  - Provides remote access to building management system
- Environmental analysis:
  - Demonstrates your greenhouse gas inventory, measuring your total CO(2) emissions against your targets over time and per building
  - Collects data in real-time to measure compliance with external regulations
  - Integrates sustainability benefits into reports to help justify demand-side activities
- Performance assurance:
  - Provides real-time data analytics to track and improve on equipment efficiencies
  - Measures and verifies previously implemented improvement projects
  - Identifies additional opportunities for building optimization
  - Demonstrates portfolio energy performance against enterprise targets, normalized for weather and building inventory changes

The Service Infrastructure

As your building's infrastructure becomes more sophisticated, so will the services required to keep it running at optimal levels. While smart buildings require traditional services, such as calibration, and test and inspection of equipment, they will also require new, digital-based services.

Data-Driven Services
The role of data fundamentally changes the focus of service from response and maintenance to predictive, strategic service implementation. Instead of only repairing equipment and keeping systems up and running, your service organization will have the ability to create strategic service plans that significantly reduce operating costs, predict future trends, and develop plans to prevent future faults and failures.

The convergence of IBMS and advanced analytics created new, digital services. The range of digital services for smart buildings extends from pre-construction planning through ongoing operations. For existing buildings, digital services are characterized as being:

- Optimized Reactive — addresses issues remotely and quickly, without dispatching a technician
- Proactive — includes monitoring and system health reports
- Predictive — helps identify potential faults before they occur, preventing future problems
- Energy Optimization — reduces energy consumption and spending
- Proven Outcomes Performance Reporting — measures key performance indicators and provides 24/7 transparency
- Digital Transparency — provides on-demand access to all service details, including measurements of key performance indicators

The Benefits

By designing an intelligent infrastructure for your new or existing building, you begin a continuous process of lowering costs, increasing productivity, and improving performance. Most importantly, you are ensuring your facility has the ability to adapt to the future with a flexible infrastructure based on open technology that can scale to new and future technology.

Reduced Costs:
For new construction, applying the planning infrastructure during the design phase will lower initial technology investment costs by integrating systems and networks to eliminate redundancies. It also lowers construction costs significantly by reducing costs of unexpected change orders. With a technology roadmap, you will have a clear integration plan in place at an early stage in the planning process. The roadmap outlines a plan for equipment acquisition and migration throughout the construction process and after the building is open. It identifies specific go/no-go dates to acquire each piece of technology needed to ensure the greatest level of compatibility with the entire system.

For existing facilities, an intelligent infrastructure reduces capital costs and operational expenses throughout the building's lifecycle. It utilizes core components of a intelligent infrastructure – a fully open IBMS, and data analytics with fault detection and diagnostics (FDD) – and allows you to maximize use of legacy systems. Old and new systems can work together, allowing you to maximize their full potential and optimize operational efficiency through:

- Detecting faults throughout your building's system and identifying the frequency of each and allowing you to prioritize repairs
- Analyzing energy supply costs to identify over-billing, redundant charges, and lower-cost energy sources
- Providing data for trained service personnel to respond to faults and interpret system reports and analysis to ensure the optimal performance of your system

Enhanced Productivity:
Intelligent infrastructure improves the productivity of construction projects by supporting a lean construction strategy. Take smoke controls as an example. Smoke controls encompass a variety of controls, as well as mechanical equipment and fire alarm equipment. Usually, specifications are generic, which creates a flawed process. For example, they don't take redundancies with fire alarm equipment into account. With a technology roadmap, you have the advantage of identifying redundancies in advance. You can specify the best-in-class fire alarms knowing how they will complement best-in-class smoke controls, increasing the advantages and value of both. Working with an existing budget, its possible to arrive under budget or, at minimum, have answers for your system up-front and avoid multiple change orders. The project as a whole benefits from reduced confusion and less time needed for coordinating meetings to manage change orders.

For existing facilities, research has shown that top-performing companies, schools, and hospitals have buildings with high-performance indices. High performance is based on quality of physical factors, including air control, temperature, humidity, and pressure control, lighting, spatial organization, and architectural design. An intelligent infrastructure provides transparency to a building's performance. It collects and analyzes building data, identifying faults, and allowing facility managers to pinpoint system malfunctions and resolve them immediately. An intelligent infrastructure supports a facility's methodology to quantitatively measure whole building performance.

Elevated Performance
When looking at new construction, adopting a planning infrastructure early in the design phase helps reduce risk and streamline schedules. With the help of a technology consultant and technology roadmap, you can reduce change orders by having a clear understanding of how systems will integrate with each other prior to writing specifications. To ensure a building performs well in the future, you can also plan today for tomorrow's technology not yet available. A technology roadmap incorporates future technology into the planning process. It improves project management while reducing project risk by illustrating how integrated technologies can improve building performance.

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Intelligent infrastructure improves performance of existing buildings by ensuring systems and controls are running at optimal levels. Building technology performance degrades over time; however, it is often not evident until major problems occur. Systems and software must be continuously monitored to ensure highest levels of performance. With intelligent infrastructure, systems are monitored, and faults are detected and reported. Service teams can pinpoint problem areas and prioritize which are most critical or costly and which can be addressed at a later date. It changes your approach to service from reactive to proactive, providing a predictive state that delivers high quality buildings that are safer and more comfortable for building occupants – patients, tenants, students, and others. In addition to improved building performance, facility managers see improved efficiency in the management of their operations.

Future Adaptability
Having the confidence to plan for the future is one of the greatest benefits of an intelligent infrastructure. For new buildings, it provides a technology roadmap to ensure that the most flexible and open building technology network is specified and new technologies and systems are adopted as construction progresses. For existing buildings, an intelligent infrastructure provides the flexibility of open technology. Past investments don't have to be discarded, but can be integrated with new systems and new solutions. It also lays the foundation for incorporating new technology as it appears on the market.

Summary

The world of building design and operations is merging with the world of technology faster than ever before. The nature of buildings, and how they function, will continue to change. In the next generation, buildings will transform from being cost centers to efficiently run assets that interact with their occupants and with the environment around them. And it is already happening. We have seen HVAC, lighting, physical security, life safety, and other building systems tap into the Building Internet of Things (IoT).

Smart buildings, with intelligent infrastructures, utilize a higher level of technology and provide a higher level of intelligence than typical buildings in the past. The future will be about leveraging data from building systems to maximize uptime, lower costs, and pre-plan for major expenditures. The future, with a new level of technology and data, requires a new approach to how we look at designing, renovating, and maintaining buildings.

To manage this transformation, building owners, general contractors, and facility managers should look to technology partners who can assist in planning and implementing sophisticated building systems. The goal is to create a truly intelligent infrastructure that will support multiple building systems and provide information and data needed to optimize operations. An intelligent infrastructure lowers costs, increases operational efficiency, and improves building performance. It also allows your building to adapt to the future, ensuring integration with new technology not yet on the market. But, perhaps most important, an intelligent infrastructure provides the comfort, safety, and security occupants need to maximize their productivity and achieve their goals.

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