# TECHNOLOGY ADVANCEMENT IN INTELLIGENT BUILDINGS: A THROUGH PREPLANNING PROCESS PERTAINING TO LONG-TERM MAINTAINABILITY

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TECHNOLOGY ADVANCEMENT IN INTELLIGENT BUILDINGS:
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## DEDICATION

This research effort is dedicated to my family, in particular to my wife, Angela and our two children, Alex and Alanna who have graciously and patiently stood by my side, supporting me through this entire process. They have spent many quiet evenings during my absence, which we all realize can never be recaptured. Additionally, they have willingly picked up extra duties without a complaint. Without their support and continued help, this effort would not have been possible. Additionally, I would like to dedicate this to my parents who laid the foundation by teaching me the principles, values and hard work discipline that have served me well in all aspects of life. I offer a special thank you to each.

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| | |
|---|---|
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| BAS | Building Automation Systems |
| BC | Before Christ |
| CCTV | Closed Circuit Television |
| CFO | Chief Financial Officer |
| CII | Construction Industry Institute |
| CSI | Construction Specification Institute |
| DIY | Do It Yourself |
| DNA | Deoxyribonucleic Acid |
| FM | Facility Management |
| HVAC | Heating, Ventilation & Air Conditioning |
| ICC | International Code Council |
| IP | Internet Protocol |
| IT | Internet Technology |
| NASA | National Aeronautics and Space Administration |
| PC | Personal Computer |
| PLC | Programmable Logic Controllers |
| PM | Preventative Maintenance |
| PPP | Preplanning Process |
| ROI | Return on Investment |
| SMA | Shape Memory Alloys |
| TV | Television |

XML (protocol)	Extensible Markup Language

911	September 11, 2001

## SUMMARY

Innovation and new technologies are changing the characteristics of buildings on a daily basis. This is because building owners are requiring more automated services, increased security, more efficient operations and reduced budgets. Therefore as building automation features are improving and reduced budgets are being required by owners, additional avenues should be evaluated to reduce long-term costs by improving facility maintainability. This should be considered as early as possible in the preplanning and design phases, as this is when the most impact can be made with the least amount of expense. The idea of preplanning for maintainability is one aspect that has not received much attention within the industry in the past. This study considers the preplanning process as it pertains to maintainability, particularly for intelligent buildings, as this is the current trend in which building construction is heading. It limitedly considers the historic aspects of construction and automation, assesses the current situation and considers the projected future needs. Based on the expectations as to where future building intelligence will lead, it was ascertained that better preplanning should be incorporated into the construction process, especially as it pertains to maintainability.

An informal survey was conducted from personnel within the federal and city government, private industry and nonprofit organizations to conceptually assess the building construction industry's need for better preplanning for maintainability, especially as buildings are daily becoming more intelligent. It was concluded that more maintainability should be incorporated into preplanning process. The research also concluded that future maintenance staffs would be affected, specifically by requiring a higher educated maintenance team.

As it relates to this effort, preplanning refers to the project concept development and includes some initial aspects of the design as indicated in the following chart at Figure 1. Though planning occurs throughout the entire process, the importance of planning as early as possible is stressed to helping reduce long-term costs.

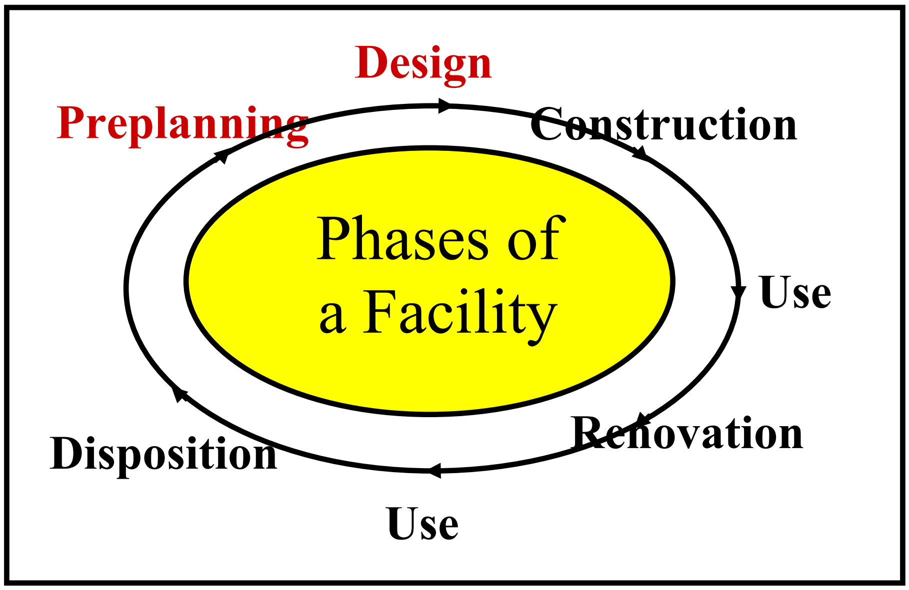


**Figure 1 Phases of a Facility**

# CHAPTER 1 - INTELLIGENT BUILDINGS

## 1.1. DEFINITION OF THE TREND

Technology is changing and improving at a phenomenal rate, and is impacting facilities and the building construction industry like never before. Buildings are becoming largely automated, service oriented and efficient. This process is impacting facility owners in many ways. Some aspects are discussed that particularly affect these changes from a maintainability standpoint.

To illustrate this point, consider a similar analogy. The automobile industry has undergone a similar course. It has not been too many years ago when automobile operations were relatively simple. They were therefore relatively easy to maintain. It was not uncommon for the average person to adequately to perform significant maintenance operations on their vehicles. Then, as manufacturers began installing more sensors, motors, pumps, computers, and electronics, more complex products resulted to where the average person would not be capable of maintaining them due to a lack of knowledge and/or specialized tooling. Today's automobile maintenance technicians must attend regular training classes to become proficient in using the latest diagnostic computers, equipment, and tools. Furthermore, during the transition process while the manufacturers were adding these new items, many times maintainability was not considered adequately in the process before the product hit the assembly line. This resulted in the necessity to remove many key components just to complete simple maintenance items such as replacing spark plugs and oil filters. This same effect can occur in buildings if adequate preplanning is not performed.

A similar scenario is occurring in the building construction industry. This is especially true due to the fact that facilities are becoming more intelligent and consequently more complicated, and more difficult to fully comprehend. This impacts owners in several ways to include maintainability, maintenance staff education levels, funding levels, and downtime, just to name a few. Therefore, theoretically, the more maintainability considerations that are incorporated into the process during the design phase, the more economically they should be able to be maintained and operated.

These changes in technology have never evolved at a faster pace, and are being integrated into facilities. In terms of integration, Budiardjo indicates that there are many definitions of the word, however there is one definition that is universally accepted[1];

> It is the process of connecting two or more systems that were not intended or designed to be connected. When you integrate two systems together to effectively become one system, you are at the same time integrating the suppliers of the systems, and more importantly, the users of the systems.

Smart buildings are becoming more commonplace daily as new facilities are constructed and older ones renovated. "We're getting more owners asking for smart buildings," according to Crockett as he quoted Cherisse Nicastro, an ESS Engineering Project Manager[2]. NeSmith indicated that Internet Technology (IT) is becoming as important in the Facility Management (FM) field, as that of engineering, architecture and business administration[3]. Sebesta stated the following about changes and controls[4].

> In the past, pneumatic and relay control logic and systems could be expected to remain relatively stable over the life of the equipment. In many cases, this life was expected to range up to 20-plus years. Maintenance and operation were consistent year after year, and very little training was required to ensure reliable operation through the life of the equipment once a person was competent in this technology.
>
> Those days are over. In one extreme case, an industrial client made a decision to totally replace a PLC-based [programmable logic controller-based] process control system before it was even fully operational. Complete changes in system hardware and software configurations,

> capability, and compatibility with higher-level data and communication integration systems affect the decisions we make at the plant and operations level more than ever before. This is only the start.
>
> Total integration of operations, facility management, utility procurement, asset management and process operations will be the norm within the next five to 10 years.

Facility management, automation and technology are all headed is this direction. Carry this concept further, and intelligent campuses or municipalities are the logical result. Cunningham and Rainey indicated that there are a few institutions that have already realized the benefits of having "intelligent campuses" through voice/data communication aspects[5].

## 1.2. SMART/INTELLIGENT BUILDINGS

This leads to the question, "What is an intelligent or smart building?" What would be an appropriate answer within the Facility Management (FM) community? What parameters specifically establish smart building criteria? Would it be energy efficiency, technologically advanced self-monitoring operating systems that require only minimal manual participation, green and renewable resource aspects, utilization of sophisticated security devices, low maintenance requirements, low operational costs, or a combination of these criteria? This research considers the aforementioned aspects as they apply to building "smartness" or "intelligence" and looks forward to where technology will lead in the future.

## 1.3. SMART BUILDINGS DEFINED

Smart Buildings have been discussed for years, in regards to the criteria that create such facilities. Considering the technological purist intent, a smart building would be a facility that performs independently and almost mutually exclusively of human interaction. This would include reacting and adjusting to environmental changes to maintain adequate working conditions within the facility when humans are present either during or after normal working hours. However, considering that most organizations have limited funding, an expanded version of the definition could include the incorporation of smart business decisions. These smart business decisions would specifically pertain to facility related characteristics that use technology and contribute to smart building systems for the purpose of yielding a higher return on investment (ROI) in the process. These attributes may not necessarily contribute to the degree of each facility's intelligence, but may help support the smart building applications. For example, utilizing in-slab radiant heating and cooling techniques that capitalize on off-peak electricity rates in and of itself do not necessarily constitute building intelligence, though it can be a smart business decision that could be an extension of the actual smart building characteristics. Therefore, if one ties a radiant heating technique into a computer controlled operating device that automatically reacts to the facility's environment, it becomes part of a smart building system.

Therefore, by interlacing smart building techniques with good business decisions, cost savings should result. McDonell stated in reference to construction, the additional expenses for the special materials many times are off-set by the savings generated by the mechanical equipment and plant reductions[6].

> Integrated design can lead to some very innovative solutions without compromising budget or "constructability." Two of these solutions, which work in tandem, are radiant cooling/thermo-active slab system and displacement ventilation systems. These can result in building energy performance up to 70 percent below conventional systems designed to ASHRAE 90.1 criteria, and at no net premium costs.

Annual savings of up to 70 percent in utility costs is an extremely significant factor in the ROI, particularly when this can be accomplished at no or very little additional upfront costs. When it is compounded over the life of the facility, it results in saved revenue per square foot and a better ROI.

This concept expanded from individual facilities into smart campuses and municipalities. Smart building concepts began emerging on university campuses by the integration of energy management, fire protection and security systems, using building-automation system (BAS) and controls[7].

### 1.4. FINANCIAL CONSIDERATIONS A DRIVING FACTOR

The impact of finances is rarely exempted from the evaluation criteria when building owners and investors make decisions to construct smart buildings. One major aspect of this is the ROI. Brand stated about workplaces that "Savvy businesses are thinking in terms of revenue per square foot not just cost of square foot per employee[8]." Smart building advantages typically result in cost savings not only in operations and maintenance, but also can even out in construction. For example, effective uses of lighting to include daylighting, efficient new glazes, task lighting, photovoltaics, employment of exterior shading devices, etc. reduce each respective facility's heating and cooling load requirements and therefore results in reduced HVAC equipment sizes. Smaller equipment sizes reduce quantities and sizes of supporting materials such as ductwork. This in-turn results in construction as well as operational cost savings, and can lead to improved customer and organizational leadership satisfaction.

McKew believes that monetary driven facilities are really the smart ones[9]. This is based on the fact that financial concerns (or the bottom line) are the ones most important to businesses. McKew indicated that owners can measure the pecuniary factors such as:

1. First Cost, budget-to-actual
2. Life Cycle, budget-to-actual
3. Operating-Cost (energy), budget-to-actual
4. Operating-Cost (labor), budget-to-actual

These monetary aspects can help provide the consistent measuring stick in order to establish benchmarks, which in-turn can lead to evaluations and comparisons between facilities. Furthermore, once the evaluation is conducted, the truly smart buildings are the ones that yield the greatest ROI.

## 1.5. THE FIRST STEPS

Initial efforts in energy systems focused on the reduction of energy utilization, primarily initiated in the 1980s when utility prices skyrocketed. Considering that typical industrial motors annually consume energy in such quantities that the operating costs equate to five to 10 times the amount of the equipment's initial capital costs[10], it is not surprising that electricity was a significant consideration in the goal to reduce consumption. Lower consumption rates help justify equipment replacement costs when quantified savings can be achieved. Automation ensued, incorporating further improvements and efficiencies.

The University of Delaware managed two ice rinks, one of which was about 30 years old and the other 12, both of which needed upgrades[11]. The university worked with their local utility provider in designing a $1,350,000 project that used integrated controls, energy efficient chillers, better lighting, energy recapturing systems, and improved monitors. The selected goal was to recoup enough guaranteed energy costs over a 10-year period to completely pay for the project. After the project and commissioning were completed, the facilities consumed 1,721,400 kilowatt hours of electricity and 5,845 thousand cubic feet of natural gas annually. Previously the facilities had consumed

5,084,150 kilowatt hours of electricity and 10,638 thousand cubic feet of natural gas on an annual basis. The first-year savings exceeded the guaranteed quantities by 109% and 154% respectively, and thus generated the revenue to pay for the project.

**Table 1 Utility Savings**

| Utility | Previous Annual Consumption | New Annual Consumption | New Annual Reduction | Percent Reduction |
|---|---|---|---|---|
| Electricity kwh | 5,084,150 | 3,362,750 | 1,721,400 | 33 |
| Natural Gas CU Ft | 10,638 | 4,793 | 5,845 | 54 |

Fire protection and security systems were also integrated into this project, but it was difficult to quantify direct savings as these systems depend on one-off type mishaps.

## 1.6. TOTAL CONTROLS INTEGRATION

The initial smart building efforts laid the foundation for other systems/components to follow. Total systems integration via controls is the emerging technology that is paving the roadway to really smart buildings. Bernstein stated[12],

> Today's open systems marketplace is forcing the buildings industry to rapidly change how business is being done. Manufacturers are embracing the concept of open systems at a staggering rate and the benefits are being realized daily. On the forefront of the emerging technologies are the control systems that combine multi-vendor product and multi-subsystem integration into a common, cohesive building system architecture. The advantages of a single infrastructure reach into almost every aspect of a facility including reduced up front construction costs, lower life cycle costs, improved system management, enhanced back office reporting, better service, and proactive maintenance.

Facilities managers, as a result, "can expand and contract at will because they are not locked into long-term contracts, single source product suppliers, or closed tool-sets" according to Bernstein. The analogy was made to the large computer manufacturers in the 1980's who have been "swallowed up or merged with more progressive companies" also according to Bernstein. This is a ramification of standards and defacto standards. For example, IBM developed the PS2 mouse port, which now has worldwide usage. As the defacto standard, the PS2 mouse was accepted globally by industry. The same applications apply to the facility related control technologies. Standards are being adopted from defacto standards, from ideas and products brought to the market by companies. Therefore, independent systems integrators (who are able to integrate systems from literally hundreds of manufacturers) are emerging into the building construction scene. Consequentially, they are able to seek bids from multiple manufacturers and develop the right package for the best price. The results can be phenomenal, limited only by the imagination.

Redstone, a UK firm, was interested in developing long term partnerships with their clientele and began promoting the concepts of 'buildings built for business[13], further expanding upon the initial smart building foundational systems. Their web site states, "This integrated solutions and services suite brings extraordinary efficiency to high capacity site management – helping you provide excellent service and security, reduce overheads and create new channels for revenue generation." Their smart building projects integrate the use of Intelligent Building Management Systems, broadband access, wireless technology, Internet access, Internet Protocol (IP) Telephony, broadcast systems, cable television (TV), closed circuit television (CCTV), security and surveillance systems using interactive voice recognition, access and building control systems, fire systems, heating, ventilation and air conditioning (HVAC), lighting control, and elevators and escalators all in concert to maximize the benefits for all parties involved, predominantly where cost savings and revenue generating opportunities exist. Previously, all these systems operated independently from each other, but companies such as Redstone[12] felt it was time to 'think outside the box' and integrate some or all of these systems.

Further expanding facility smartness, the Intelligent Building Technology Division of Parsons Brinckerhoff Consultants designed the integrated mechanical and electrical systems of Singapore's 52-story, 70,000 square meter (753,473 square feet) downtown Capitol Tower Building. To accomplish this, they added lighting, window blinds and elevator controls to the normal BAS systems[14].

> With a tenant's ability to use his or her own PC to monitor and set the office temperature, find an open parking space via an intelligent parking guidance system and catch up on the latest financial news while taking a ride in an elevator, Singapore's Capitol Tower seems to have raised the bar for intelligent buildings.

This facility offers individualized office temperature setting ability, smart parking, and advanced telecommunication initiatives. Tenants, from their own PC workstations, can adjust the temperature within their workspace; reserve an executive elevator to arrive at a particular floor at a specified time; monitor their areas through the security cameras; and reserve a parking space through an automated car park system. The car park system welcomes arriving personnel, informing them how many spaces are vacant on each level as well as their locations, and provides directions to the closest available space. While riding in the elevators, individuals can watch cable TV programs. One of the best characteristics of this system is that the BAS interface and protocols are non-proprietary and therefore enables the owner not to be locked into one manufacturer. Additionally, as this system had to be highly customized, it will be more adaptable for future applications.

This has only recently been made possible through technological improvements in communications. Current leading technology indicates that the keys to smart buildings is having one central computer that is able to control several sub-systems (brains) and a highly responsive communication link (nervous system) that operate each of the sub-systems.

For another example, a nonprofit research organization needed to upgrade their primitive BAS system for a laboratory[15]. When the quotes were received, the large controls companies had exorbitant prices, indicating that the retrofit would necessitate the complete removal of the old system. Therefore, the director of facilities and services and his staff began an in-house do-it-yourself (DIY) project, completing the work themselves. Though they had some hurdles, their company was able to use some of their existing system in installing the new BAS controls, at significantly reduced prices.

### 1.7. NEW TECHNOLOGIES

Technology, as stated earlier in the facilities arena is coming at a pace faster than ever. These changes will mold the way facility managers and their maintenance staffs form the processes of tomorrow. New methodologies and materials continue to emerge which help facilitate smart buildings. For example, utilizing a raised-access floor for wiring and ventilation just makes sense. Furthermore, materials are becoming smarter. Chang Liu, a professor at the University of Illinois led a team that developed a smart brick that monitors a building's temperature, vibration, and movement[16]. This brick uses wireless technology to report critical information that could be useful to firemen or rescue workers in a blazing skyscraper as to the structure's soundness of an earthquake-damaged facility. Other materials that are beginning to emerge are ones made of shape memory alloys (SMAs) used in control actuators can be deformed when cool and reassume their original shape when heated[17]. Robotics will also have a critical role in smart buildings in the future. Robotics has progressed to the point to where it is being used in automated self-servicing milking stations in dairies. This enables the cow to be milked without the presence of the farmer, by using laser technology, biomimetic paradigms and robots. Based on the rate at which improvements have been made in the last few years and the newer open platform based controls systems, technology will continue to be developed and used to make facilities even more intelligent in the future.

The interrelationship between innovation and success are eloquently highlighted by Naughton, who stated[18],

> Advances in technology, changing customer needs, shorter product life cycles, and global competition are making innovation not just a luxury but a practical necessity. Outside-the-box thinking, once a radical notion, is rapidly becoming a cliché.... The lesson is clear: innovate or fall behind. Envision the future, imagine your role in it, and chart a course to make it happen based on what you do best. Now is the time to convert challenges into opportunities.
>
> Understanding Innovation
>
> Although more organizations are talking about innovation, many do not have a real sense of how to achieve it. They create new ideas without focus, or even worse, without creating value. The fact is, innovation is a process of generating fresh ideas for the purpose of creating value for your customers….It has been said that innovation doesn't come from a few brilliant people but from getting the most out of many ordinary people. Time and again, we have seen this notion proven in successful companies who encourage innovation at all levels of their organizations. These companies know that good ideas can come from anywhere.

Cunningham and Rainey addressed the benefits of “Intelligent” buildings utilizing some of the latest technological advances available[19]. In particular, their research indicated that a blend of voice/data communication with automation can be extraordinary, particularly in safety and security as well as for greater customer service. For example, egress control, alarms and smoke control via fans and dampers, and automated closed circuit TV for personnel verification were all automated at an educational facility. They found that by using these automated systems; they reduced operator errors, provided more consistent service and required less manpower. The automated systems, according to Cunningham and Rainey, also work well in utility management[18]. Historically, this is one area that has not been considered to a great extent for cost savings. They quoted an unnamed university CFO as stating, "I count every pencil and paperclip on campus, but we spend millions of dollars on electricity without knowing where a dime of it goes."

Pertaining to building technology and change, Hutchings illustrates this idea as he looks back in retrospect over the twentieth century's last two decades in the building construction industry[20]. He stated,

> In those two decades I have seen many changes that foreshadow even bigger changes in the future for the American builder as the new century accelerates toward us. Of all the things we build with today, 75% have been invented within the last 50 years.
>
> Of those, 80% have been invented in the last 10 years. It is estimated that, of all the things we will be building with by the year 2025, 90% have not even been invented yet.[19]

## 1.8. TECHNOLOGY FEASIBILITY AND REALISM

Though it is probably accepted that organizations must keep up with the technological changes to remain competitive, it too could be disputed that the absolute latest and greatest is not completely necessary. Korka, Oloufa and Thomas concluded that sophistication of mission of a facility did not dictate the level of sophistication of a computerized maintenance management system based on research at naval facilities[21]. In fact, the concluding governing aspect was that each installation should have an effective software system that worked well. Such systems would only require accurate data to be retrieved for the purpose of assisting in the decision making process. It was not required to be overly sophisticated. But, it was required to provide accurate and timely data.

Therefore, considering the abundance of technological changes in the last few years, there should be a balance of intelligent building features to each structure's purpose.

Once this balance is realized, then appropriate preplanning in the design phase can help meet the owner’s needs.

# CHAPTER 2 - PREPLANNING

The historic concept of incorporating preplanning into the process is that organizations will construct the right building for the right purpose to meet organizational goals. However, as new technology is introduced into the market place for facility related purposes and as more building owners are requesting facilities with intelligent characteristics, it could be acknowledged that smart buildings gradually are becoming more commonplace. Therefore, it could be further acknowledged that intelligent buildings are beginning to develop into somewhat more of a defacto standard on a daily basis as new facilities are constructed and older one are refurbished. Furthermore, considering the recent fierce marketplace competition, and the documented significant life-cycle savings possibility via the facilities departments, it only makes sense to incorporate better preplanning in the design phase. This should reduce costs while providing the increasing intelligent building characteristics.

## 2.1. HISTORY OF FACILTIY PLANNING

It is often helpful to look back to history in order to see clearer the future. The idea of planning is not a new concept. In fact, the Holy Bible states that long-term preplanning is a wise idea. The apostle Luke recites an account where Jesus Christ indicated that long-term planning pertaining to spiritual matters is essential, where he used a specific facility related issue. He stated in Luke 14: 28-30[22],

> 28. For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it? 29. Lest haply, after he hath laid the foundation, and is not able to finish it, all that behold it begin to mock him, 30. Saying, This man began to build, and was not able to finish.

The substance of this analogy would be equated to the facility owner's need to preplan, so that he will not suffer long-term, negative consequences.

The Romans learned the value of planning the hard way. According to Magnus Edizoini, the Romans realized the need to develop a master plan for their city as early as the fourth century BC[23]. After the Gauls sacked Rome in 390 BC, which consequently was attributed to chaotic urban development, the city was in need of rebuilding. Edizoini quotes one of the most comprehensive ancient accounts in history (Livy, V, 45; 2-5) in reference to the rebuilding of Rome. He states,

> The rebuilding of the city was carried out in a disorganized manner. The state provided the tiles and authorized the quarrying of stone and sawing of timber everywhere, provided there was a guarantee that construction work would be completed within the year. In the resulting haste, no care was taken to lay the streets along straight lines, because the construction was being carried out in an open space, without any account being taken of anyone's property boundaries. This is the reason why the ancient sewers, which previously ran across public land, now often pass beneath private houses, and therefore the city seems to be the result more of chaotic appropriation than rational subdivision[22].

According to Edizoini, this situation of poor preplanning was also recorded by other historians of their day to include Capua (in De lege agraria, II, 96) referring to 'narrow streets and cramped alleys,' and Tacitus (Annals, XV, 43) referring to the disorganization of the city[22]. The author further feels that the property lines were not distinguishable, as that would have given rise to the building of straight streets as was found in some Latin colonies such as Norba, that were founded about that same time and were built on straight grid patterns.

Unfortunately, the value of preplanning too many times is not fully realized until only after the project is completed when the cost to re-accomplish it would be drastically higher and the process significantly more difficult. The whole concept of planning is to look ahead into the future, and as much as possible use all of the information that is available, to determine the best options that should be used.  Many individuals do not realize the potential problems that could be alleviated by incorporating thorough forethought and planning into their processes.

### 2.2. ACTION ORIENTED CULTURES

Some cultures tend to be action oriented such as America[24].  Once business decisions are made to accomplish specific projects and the organizational leaders have conceptualized their preferences, as to what the end objective should be, they expect it to be accomplished as expeditiously as possible.  However as unfortunate as the case may be, oftentimes organizational leaders do not realize that the process to complete the project can be as important as the final product.  This includes both short and long-term costs, as well as the loss of benefits to the institution.  This is especially true if it does not pertain to their core business.  The idea of delaying a project for planning is considered a waste of time by some people.  What these individuals don't realize is that the idea of 'measuring twice and cutting once' is not only a good idea, but also makes practical sense especially when it comes to their organizations' second most costly expenditure – their facilities[25].  Cotts illustrates the need for facilities personnel to plan ahead in developing innovative solutions as he states, "After payroll, facilities are usually the greatest component of a company's administrative expense.  Some facility departments have saved or even avoided costs in the 30 to 35 percent range, with no diminution of services, by applying sound principles of planning, lease management, and energy management[26]." The choice of this author would be to avoid the costs initially.

One of the first steps in developing a good plan is to determine what needs to be planned. Too many times, organizations have built the wrong building for the wrong purpose simply because there was no plan and overall organizational direction. This is not necessarily surprising as facilities are not the core business of most organizations. Furthermore, there are no cookie cutter answers to this dilemma, as each organization is different. However, there are some general procedures that help in this process, such as developing master plans and design standards, providing that the organization has a significant quantity of facilities. After these plans and standards are developed, then individual facilities should be designed. Hence, the macro plans are developed first leading up to the micro plans. The macro plans would incorporate the degree to which facilities should incorporate intelligent features, whereas the micro plans would be the execution of the macro plans within each facility.

## 2.3. HOLISTIC DESIGN

Building design and construction will most likely continue to make the most of the resources available at the respective time. New design approaches are being offered daily to the facilities related industry due to; innovative technologies utilizing open control systems, higher energy prices coupled with more fierce market competition, and owners' demands. Therefore, plans need to remain as plans and not structured, unyielding rules to where there is no ability to capitalize upon new technology or innovative processes. Currently, architects and engineers are considering to a higher degree smart building initiatives that encompass operational and construction costs savings initiatives, to develop the best facilities within their resource limitations. As referenced previously ([13]), it is not only now possible to interface multiple unrelated systems that synergize together in making intelligent buildings but is becoming relatively ordinary.

Finding the right balance in determining facility intelligence levels and organizational mission should be accomplished during the strategic pre-project planning phase. Strategic planning is not something that just happens. It normally requires a considerable amount of time, energy and funds to be diverted from present day resources (other requirements) into a decision-making process that in most cases yield long-term benefits provided it's accomplished properly and good assumptions are made in the process. These benefits can be as simple as increasing a small company's profits, or as complex and difficult as redeveloping and improving a metropolitan zoning plan involving literally millions of peoples' lives and livelihoods. The idea is to gather as much pertinent data as possible, and to maximize its use in making the best decisions from a business perspective. There is no set timeframe for which planning is to be considered as strategic. Cotts deems three to 10 years to fall into this category depending upon the size of the organization and the degree to which it would be considered value-added[27]. However, there is not a set time limit. For example, some small companies may consider two to three years to fall within this category, whereas some large governmental departments and corporate organizations may forecast out 25 years or even more. The key concept is to plan to the extent that it will be value added.

## 2.4. MASTER PLANS

Many successful organizations use master plans to develop their long-term objectives. They incorporate current and long-range plans in one document, which establishes a 'facilities road map.' These master plans should include the current and projected future requirements, assets, major maintenance and improvements schedules, and general funding requirements ascribed to a timetable to meet the organizations long-term needs. Master plans are defined as a long-term outline of a project or government function[28]. According to Kaiser and Kirkwood, master planning should incorporate the following elements considered over a five to ten-year horizon[29]:

1) Land use and site planning
2) Design guidelines
3) Vehicular/pedestrian circulation and parking
4) Infrastructure

In essence, this drives the organization's capital program, by helping make smart investments in real property and in zoning issues. Each of these four aspects will be discussed at length in the following several pages.

Master plans should incorporate maintenance audits to establish a baseline as well as help develop a prioritized schedule of works. Companies such as Facility Management Engineering, Inc.[30] conduct such audits, and in turn give organizations a realistic understanding of their maintenance activities with recommendations for improvement. They also reveal areas where budgeting should be focused, and review maintenance strategy effectiveness and performance related issues. Furthermore, companies such as ABS Consulting conduct a varied form of this called "Risk-based Maintenance" that involves integrating the risk factor into the decision making process. This helps organizations focus their resources on their highest priority equipment by assessing and identifying critical spares to maintain in bench stock, optimizing planned maintenance activities, and establishing inspection and testing criteria. The Pacific Northwest National Laboratory applied a similar risk-based maintenance program at their Fluor

Hanford Spent Nuclear Fuel Project[31]. They expect to save $1 million over the remaining five-year life of their project.

Credit has been attributed to superior master planning that enabled a pharmaceutical company to continue its research and development while it was undergoing a complete renovation[32]. This project demolished three facilities, constructed three new facilities and renovated another two, at a cost of $75 million. Their constant planning and communication resulted in a tremendous success.

## 2.5. LAND USE AND SITE PLANNING

Land use and site planning is a major factor for large organizations as well as the ones that are expanding. To accomplish maximum practical land benefit, master plans should incorporate visual references. This is a facilities concept visualization in relationship to space. The following aerial photograph was from University of Washington's Master Plan[33]. It is subdivided into computerized sections that can be selected with a computer mouse to highlight areas. These indicate major subdivisions to show land usage, construction phasing or facility site planning, depending upon the program requirements.

**Figure 2 University of Washington Master Plan Photograph**

## 2.6. DESIGN GUIDELINES

Design guidelines are organizational standards that will help the organization reduce maintenance costs if properly developed. For an overly simplistic example, it is unnecessary to maintain 20 separate faucet types in a residential housing complex. That practice would necessitate the stocking of unnecessary repair parts and specialized tools to maintain each of the different types of faucets. Whereas if there were only two faucet types specified that met the functional and aesthetic needs, one for the kitchen and one for the bathroom, then significant benefits could be realized. Such benefits may include the reduction of maintenance bench stock items, the possibility of greater quantity discounts received, better and faster service provided to the customers, the reduction of many specialized tool requirements, and the possibility fewer vehicles could be required.

Facility design standards help accomplish this same objective on a more macro level. Design standards should help maintain consistency in core aspects of the facilities, while at the same time not being overly stringent to remain flexible, permitting the utilization of the new emerging technologies. This is probably the most important aspect of design standards for smart buildings. The basic premise is to provide a facility that meets the organization's purpose, while being constructed with people in mind, and hopefully reducing maintenance costs.

## 2.7. BENEFITS OF STANDARDIZATION

Practical consistency is one benefit of adherence to a design standard. Mitchell in the Preface to his book published in 1915 titled "Building Construction" indicated his desire for uniformity in the construction business as he stated, "The aim of the Author has been to give, with conciseness and accuracy, a clear statement of the principles which should govern the execution of building work,"[34] Standardization would reduce the requirement to produce as many different parts and supplies in various sizes and could therefore reduce logistical costs. Furthermore, if many repair and replacement parts were standardized, it would be much easier to find these parts from more supply vendors, and they would probably be available for longer durations of time (i.e. several years from the present) thus possessing the ability to reduce long-term maintenance costs and availability. To fully understand the necessity of standardization, it is appropriate to look back in history pertaining to the development of some initial standards that were so important they were made into laws.

### 2.8. HISTORY OF STANDARDIZATION (Specifically Pertaining to Laws and Codes)

Roman building laws date back to 450 B.C. which were a form of design standards imposed on individuals by the government. These Roman laws required right-of-ways, public access to riverbeds, property rights and open spaces around individual dwellings, though compliance was not often enforced. The great fire in Rome during Nero's reign illustrated the need to enforce building codes, which was incorporated in the subsequent rebuilding of the city. Their master code restricted building materials and limited the heights of facilities. England later followed suit, establishing it's earliest building code in 1189 that placed community requirements on neighbors and rain gutter restrictions on households. Similar communal type laws began to be developed in Germany in 1275, that required builders to channel rainwater gutters onto one's own property as well as having their yard enclosed with a woven fence, and limited the locations of pigsties, privies, and baking ovens (3 feet from boundary line)[35]. Unfortunately, as was in the case of Rome, many of the stricter code requirements were developed after major tragedies occurred such as the 1666 Great Fire in London that destroyed an estimated 80% of the city[36]. The following year, Parliament established classes on buildings, restricted building materials, and required permit fees for inspections. A continent away, Benjamin Franklin in America began penning thoughts to a building code in a letter dated 1787[35].

Most of the above referenced statutes are still in existence today, in some form or fashion, either in law and/or in building code. Just as in the days of yore when codes were first developed, code today is intended "to serve as a comprehensive regulatory document to guide decisions aimed at protecting the public's life, health, and welfare in the built environment." as illustrated by the Southern Building Code Congress International, Inc.[37] in 1999.

Design standards for organizations today serve many of the same purposes, as well as transcend them. Design standards should promote the safety, public interest as well as the goals and mission of the organization. Furthermore, organizations should begin fine tuning them to the extent that they can alleviate unnecessary costs, specifically in the maintainability aspect. However, it can not be overemphasized that though there is an inherent need for consistency, organizations should also permit flexibility when necessary.

## 2.9. TRAFFIC, PARKING AND INFRASTRUCTURE

The third aspect of master planning is traffic, parking and infrastructure. Vehicular and pedestrian traffic related issues as well as utility infrastructures are many times the items that receive the least amount of attention and are often the first items in a contract to be cut out due to funding shortfalls. This has historically been because they can be severed from an associated project, without hindering the overall project. The rationale to justify these decisions is based on the fact that they can at a later date resume where they were left off. However, this does not diminish the importance of these facility support systems, especially as they pertain to intelligent building characteristics. A good master plan will consider smooth traffic and pedestrian flow, as well as ensure that the utility systems will be able to handle the new loads. Idealistically from a master planning phasing aspect pertaining to municipalities that need major renovations and upgrades, it would be appropriate to adhere to the following steps:

1. Develop the overall master plan
2. Determining the site locations of the facilities
3. Complete the underground aspect of replacing utility systems
4. Renovate the facilities
5. Resurface and/or replace the streets
6. Construct the sidewalks

This permits the underground work to be completed and enables the new utility systems to support the plan. Next, the facility construction and renovation work is completed, and then the streets. This prevents the streets from being damaged during the major construction activities. Lastly, the sidewalks are placed. More than one sidewalk has had to be demolished for additional construction to be accomplished. Furthermore, pedestrians will help define the areas where sidewalks are most beneficial. Too many times, sidewalks are placed in areas that look good to architects, but do not meet practical usability criteria. Then trails are made through hedge rows, across the grass, and other places where the sidewalks should have been built originally.

Though traffic, parking and infrastructure could appear relatively insignificant in the overall facility construction process, it can be a significant aspect in intelligent buildings such as was the case in the Singapore Office Tower previously referenced ([13]) pertaining to their smart parking capabilities. Furthermore, considering security aspects, lighting, and customer convenience, pedestrian and vehicular traffic as well as infrastructure can be vital to intelligent buildings.

The Construction Industry Institute (CII) recognized the importance of preplanning in the design phase of a project and responded by developing a worksheet to include maintainability aspects[38]. Copies of the un-weighted worksheets are located at Appendix C, and the weighted ones at Appendix D. There is a complete set of guidelines and explanations that accompany these worksheets in the book produced from CII, but these worksheets provide the concept as to their initiative to conduct better preplanning features.

**2.10. CHAPTER SUMMARY**

It was one time said that a truly wise man will learn from others mistakes. If we look at ancient history and not-so-ancient history, we can learn that thoroughly planning projects through will result in greater benefits for everyone involved in the process. This can result in better productivity, increased profits, as well as better morale and a myriad of other benefits for the organizations that plan ahead. The American culture is increasingly becoming more impatient, wanting results yesterday. However, when decisions are made in haste, they typically are not the best ones for the organization. Master plans, especially for larger organizations, help in the funding allocation process and ultimately are best considering long-term advantages. The bottom line is that planning in the facilities management is the right decision for the organization in a plethora of ways.

# CHAPTER 3 - FACILITY MAINTAINABILITY

Maintainability, for the purpose of this study, would be defined as a combination of making the maintenance process as simple as possible and achievable at the lowest possible cost. Though significant research has been dedicated to building sustainability in the design process, relatively little attention has been given specifically to maintainability. This may be due to the fact that only recently have facilities departments been considered a contributing source to the organizational ROI. Additionally, some could consider that sustainability is a specific sub-factor of maintainability, which is a fairly accurate assessment. This is due to the fact that if materials are durable and will hold up for long periods of time, little maintenance will be required to be performed on them. However, maintainability encompasses a much broader scope. It is possible for facilities to be constructed from sustainable materials, yet not easily maintainable. This could create long-term maintenance problems. Throw into the equation highly automated, interrelated and integrated controls systems, and it provides the basis of a costly product. This is especially true as more technology is developed and used in the building construction industry. This leads to the two primary aspects of maintainability that affect organizations: 1. Through the actual maintainability of the facility, and 2. Through the impacts it forces on maintenance staffs.

## 3.1. ACTUAL FACILITY MAINTAINABILITY

The Construction Industry Institute (CII) initiated a research team dedicated to investigate the long-term life cycle costs due to facility maintainability[39]. The authors state in reference to the manufacturing industry;

> To successfully compete in today's global economy, manufacturing companies must continually examine their business and production

> strategies. Companies are incorporating technology to trim processes to be more efficient and cost effective, while simultaneously producing high-quality results. In this environment, companies simply can not continue to design exclusively for short-term goals, overlooking life-cycle costs of operations and maintenance. Ignored life-cycle cost factors will return to negatively impact equipment productivity and availability. Planning and designing for maintainability improves production availability, thereby increasing profits. Accordingly, maintainability strategies should be further examined.

Therefore, the CII research team developed a model process consisting of six milestones to acquire both corporate and manufacturing department buy-in ([38]). The milestones are listed in the following table.

| | |
|---|---|
| 1. | Commit to implementing maintainability |
| 2. | Establish a maintainability program |
| 3. | Obtain maintainability capabilities |
| 4. | Plan maintainability implementation |
| 5. | Implement maintainability |
| 6. | Update corporate program |

**Figure 3 CII Milestones**

These six milestones are divided into two categories, corporate and project level. Milestones 1, 2 and 6 are geared for corporate level, whereas 4 and 5 are project level milestones, and 3 serves as a formal transition between the two levels. Furthermore, the benefits of an effective maintainability program are listed as indicated in the following table.

| | |
|---|---|
| 1. | Improved equipment reliability |
| 2. | Increased equipment availability |
| 3. | Improved equipment performance |
| 4. | Control of maintenance costs |
| 5. | Application of innovative technology |
| 6. | Increased safety |
| 7. | Smooth project transition with compressed start-up time. |

**Figure 4 CII Benefits of Pre-project Planning for Maintainability**

These principles were tested in a case study for the primary purpose of better establishing maintainability criteria. As a result of this evaluation, many benefits were realized for the subject manufacturing plant, many of which will not be fully recognizable until some time in the future.

## 3.2. IMPACTS ON MAINTENANCE STAFFS

Security, safety, and operating systems are some of the primary facility issues which are becoming so metamorphosed and automated that it is affecting maintenance staffs. This, in turn, necessitates some degree of change to the maintenance staff which must be addressed. Furthermore, today's maintenance teams must look beyond their usual roles to adequately prepare themselves and their organizations for the current perplexities with which they are being faced.

## 3.3. RESEARCH ALTERNATIVES TO THE STATUS QUO

It is generally accepted in the facility management field that building managers were promoted maintenance technicians who had a fair knowledge of the physical plant or some specific aspect of it, and had very little management training. They were usually higher performance mechanics or tradesmen who were deemed worthy of promotion. Their foundation for decision-making was normally based on the most economical means to accomplish a specific task rather than long-term, strategic or analytical calculations. Historically, most maintenance managers and their staffs have not been involved in the big-picture management of their businesses or any strategic planning activities. This was documented by Cotts who stated that most facility managers are viewed as technical facility managers and not as business managers[40]. However, times are changing.

Cotts further stated that the facility managers who have thrived, have shed the perception of technician and adopted characteristics such as business leader, mentor, strategic planner, resource obtainer, financial manager, networker, survivor, spokesperson, information manager, and innovator[41]. He illustrated the need for facilities personnel to 'think outside the box' to develop innovative solutions as he indicated (previously referenced) that facilities programs can save or avoid costs up to one third of their annual operation budgets, without any reduction in services[42]." To help facilitate these savings, maintenance staffs and facility managers should be acting in the present and with a clear vision of the organizations' long-term, big-picture plan.

All of the above leads to the focal point of how this affects the maintenance staff. It must be noted that maintenance departments and even facilities sections are not typically the core business of most businesses. Therefore, they may rank high on the list of possible candidates for outsourcing. The American School and University reported that the Detroit school district contracted with Aramark ServiceMaster Facilities Services for $78.5 million, 10-year contract to maintain their school facilities, due to a severe backlog of maintenance requests[43]. To prevent this, it is imperative that maintenance staffs keep up with technology while providing good customer service. Cotts indicates that a good maintenance staff will be technically competent and aware of all capital projects[44]. He also states that they will be staffed at a level to inspect for deficiencies and ensure that all maintenance and repair work is accomplished; that they will be provided adequate training in technical skills and management; and that they will be proactive. He further emphasizes throughout his work the necessity of providing stellar customer service.

An additional innovative strategy that was tested by the National Aeronautics and Space Administration (NASA) through another CII initiative was to place all functions (design, construct, operate, and maintain) under one contract to obtain efficiencies and effectiveness in the project delivery process[45]. A similar process was followed utilizing the six milestones for this project. The initial outcome of this project indicated favorable results to this process; however, the long-term results (not yet available) will be most important.

### 3.4. INFORMAL SURVEY

To determine the effects of how maintainability should be considered during the preplanning aspects of project design, an informal survey was conducted in this research. The intent of the survey was not to develop a scientific analysis, but instead to establish a conceptual basis for this study. There were 18 candidates who were chosen to participate in the informal survey, which yielded a total of 13 responses. This equates to a 72 percent survey return response. The candidates were chosen due to their personal experience and knowledge of the design/construction process. Furthermore, the majority of the participants were senior level personnel within their organizations and most were personally acquainted with the author, which could attest the high response ratio. The survey sample included governmental, private and non-profit organizations that for the most part have at least regional responsibilities if not global. Copies of several respondents' vitas are attached at Appendix B. The survey basically covered three broad areas; 1. General policy towards design standards, 2. Current practices within the respective organizations, and 3. Future status as to what consideration will need to be given.

### 3.5. SURVEY ANALYSIS CONSIDERING ALL OF THE RESPONSES

The general data received from the respondents indicated that 10 of the 13 organizations either had design standards specifically pertaining to maintainability or were in the process of developing them, which equated to 76.9 percent. Most of the facility space represented was office, industrial and other (primarily being laboratory). Some respondents provided multiple facility types in their answers. It is assumed that either the facilities were mixed use or the respondents considered multiple facilities in their evaluation. This same scenario occurs in some of the following answers as well. However, the data was calculated accordingly, as it was an informal survey with the basic intent of obtaining general knowledge. The primary purpose of the intelligent features were for automation service which received 8 responses, followed by environmental and funds savings which both received 5 responses each. The majority of the responses indicated that the facilities under consideration encompassed projects that were in design, in construction, or just completed with a total of 11 of the 14 responses.

The facilities evaluated were considered between average and above average from an building intelligence perspective. Furthermore, the degree of consideration given to maintainability was also between average and above average, with expected savings to be commensurate to the contemplation given.

The three questions within the foreseeable future status all ranked higher than current practices, indicating that it will be more important for organizations to consider maintainability within future design processes, and also indicating that it will affect the maintenance staffs accordingly.

### 3.6. SURVEY ANALYSIS CONSIDERING QUALIFIED RESPONSES

The data was re-evaluated discarding all of the respondents' data that did not rank their facility under consideration as either above average or high in the intelligence criteria. The purpose of this was to better evaluate the facilities that were considered above average or highly intelligent as to maintainability. Six responses were removed from the sample. The remaining seven responses were tallied and the data indicated higher numeric answers in every single category. This indicated that more preplanning (specifically for maintainability) was incorporated into the processes with higher expected savings. Accordingly, the future status had extremely similar trends, indicating that more preplanning for maintainability should be included in the design process and that it will significantly affect future maintenance staffs.

A copy of the survey form is included at Figure 5, and the summary and background data sheets at Figures 6 to 9.

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes ☐ - In Development ☐ - No

## Specific Facility - Current Status

2. Type of Facility?

☐ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other

For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☐ - Automation/Service, ☐ - Funds Savings, ☐ - Other

For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☐ - In Design, ☐ - In Construction, ☐ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

**Figure 5 Informal Survey Questionnaire Sheet**

**Table 2 Data Summary from All Informal Survey Responses**

## Informal Survey

### Analysis of All Responses

**General Policy**

| Question | Yes | In Devel-opment | No |
|---|---|---|---|
| 1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability? | 7 | 3 | 3 |

**Specific Facility - Current Status**

| Question | Quantity of Responses by Catagory | | | | |
|---|---|---|---|---|---|
| | Office | Industrial | Retail | Warehouse | Other |
| 2. Type of Facility? | 5 | 3 | 1 | 0 | 5 |

| Question | Quantity of Responses by Catagory | | | |
|---|---|---|---|---|
| | Environmental | Automation/ Service | Funds Savings | Other |
| 3. What was the primary purpose in installing the intelligent features of the facility? | 5 | 8 | 5 | 2 |

| Question | Quantity of Responses by Catagory | | | | |
|---|---|---|---|---|---|
| | In Design | In Construction | Just Completed | Completed w/in 1-3 Years | Completed 3+ Years |
| 4. Status of the facility Design/Construction: | 3 | 5 | 3 | 1 | 2 |

| Questions | Quantity of Responses by Catagory | | | | | Mean | Median | Mode |
|---|---|---|---|---|---|---|---|---|
| | 1. None | 2. Little | 3. Moderate | 4. Above Average | 5. High | | | |
| 5. To what degree would you consider this facility as intelligent? | 0 | 1 | 5 | 3 | 4 | 3.769 | 4 | 3 |
| 6. To what degree was maintainability incorporated into the design process? | 0 | 0 | 6 | 4 | 3 | 3.769 | 4 | 3 |
| 7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts? | 0 | 0 | 6 | 5 | 2 | 3.692 | 4 | 3 |

**Future Status**

| Questions | Quantity of Responses by Catagory | | | | | Mean | Median | Mode |
|---|---|---|---|---|---|---|---|---|
| | 1. None | 2. Little | 3. Moderate | 4. Above Average | 5. High | | | |
| 1. To what degree should future facility maintainability be incorporated into the intelligent building design process? | 0 | 0 | 1 | 7 | 5 | 4.308 | 4 | 4 |
| 2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process? | 0 | 0 | 2 | 6 | 5 | 4.231 | 4 | 4 |
| 3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)? | 0 | 0 | 1 | 6 | 6 | 4.385 | 4 | 4 |

**Table 3 Data Summary from Qualified Informal Survey Responses**

| Informal Survey<br>Analysis of Qualified Responses | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **General Policy** | | | | | | | | |
| **Question** | **Yes** | **In Devel-opment** | **No** | | | | | |
| 1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability? | 3 | 2 | 2 | | | | | |
| **Specific Facility - Current Status** | | | | | | | | |
| **Question** | **Quantity of Responses by Catagory** | | | | | | | |
| | **Office** | **Industrial** | **Retail** | **Warehouse** | **Other** | | | |
| 2. Type of Facility? | 1 | 2 | 0 | 0 | 4 | | | |
| **Question** | **Quantity of Responses by Catagory** | | | | | | | |
| | **Environmental** | **Automation/ Service** | **Funds Savings** | **Other** | | | | |
| 3. What was the primary purpose in installing the intelligent features of the facility? | 4 | 4 | 2 | 2 | | | | |
| **Question** | **Quantity of Responses by Catagory** | | | | | | | |
| | **In Design** | **In Construction** | **Just Completed** | **Completed w/in 1-3 Years** | **Completed 3+ Years** | | | |
| 4. Status of the facility Design/Construction: | 2 | 5 | 2 | 0 | 0 | | | |
| **Questions** | **Quantity of Responses by Catagory** | | | | | | | |
| | **1. None** | **2. Little** | **3. Moderate** | **4. Above Average** | **5. High** | **Mean** | **Median** | **Mode** |
| 5. To what degree would you consider this facility as intelligent? | 0 | 0 | 3 | 3 | 4 | 4.571 | 5 | 5 |
| 6. To what degree was maintainability incorporated into the design process? | 0 | 0 | 0 | 1 | 3 | 4 | 4 | 3, 5 |
| 7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts? | 0 | 0 | 3 | 3 | 2 | 4 | 4 | 4 |
| **Future Status** | | | | | | | | |
| **Questions** | **Quantity of Responses by Catagory** | | | | | | | |
| | **1. None** | **2. Little** | **3. Moderate** | **4. Above Average** | **5. High** | **Mean** | **Median** | **Mode** |
| 1. To what degree should future facility maintainability be incorporated into the intelligent building design process? | 0 | 0 | 0 | 4 | 3 | 4.429 | 4 | 4 |
| 2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process? | 0 | 0 | 1 | 2 | 4 | 4.429 | 4 | 4 |
| 3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)? | 0 | 0 | 0 | 3 | 4 | 4.571 | 5 | 5 |

**Table 4 Background Data from All Informal Survey Responses**

| Background Information Summary for All Respondents | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability? | Yes | No | In Devel-opment | Yes | No | In Devel-opment | In Devel-opment | Yes | No | Yes | Yes | Yes | Yes | | | |
| 2. Type of Facility? | Church, Social Service Centers, Apartments, Retail Centers | Office | Laboratory | Industrial | Industrial | Laboratory | Industrial | Office | Laboratory | Dormitory | Office, Industrial & Acedemic | Office | Office & Industrial | | | |
| 3. What was the primary purpose in installing the intelligent features of the facility? | Automation/ Service | Automation/ Service, Funds Savings | Other - Life Safety | Funds Savings | Environ-mental, Funds Savings | Environ-mental, Automation & Security | Automation/ Service | Automation/ Service | Environ-mental, Automation | Funds Savings | Automation/ Service | Environ-mental, Funds Savings | Environ-mental, Automation & Sustainability | | | |
| 4. Status of the facility Design/Construction: | In Design | Just Completed | Just Completed | Complete d w/in 1-3 yrs | In Construction | In Construction | In Design | In Construction | In Construction | In Design | 3+ Years | 3+ Years | Facilities In Design, Constr & Just Completed | Mean | Median | Mode |
| 5. To what degree would you consider this facility as intelligent? | 2 | 3 | 5 | 3 | 4 | 5 | 3 | 4 | 4 | 5 | 3 | 3 | 5 | 3.77 | 4 | 3 |
| 6. To what degree was maintainability incorporated into the design process? | 4 | 4 | 5 | 4 | 3 | 5 | 3 | 3 | 3 | 4 | 3 | 3 | 5 | 3.77 | 4 | 3 |
| 7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts? | 4 | 4 | 5 | 3 | 4 | 4 | 3 | 3 | 3 | 5 | 3 | 3 | 4 | 3.69 | 4 | 3 |
| 1. To what degree should future facility maintainability be incorporated into the intelligent building design process? | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 5 | 5 | 4.31 | 4 | 4 |
| 2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process? | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 3 | 5 | 4 | 4 | 5 | 4.23 | 4 | 4 |
| 3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)? | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 4 | 4 | 3 | 4 | 5 | 4.38 | 4 | 4 |

**Table 5 Background Data from Qualified Informal Survey Responses**

| Background Information Summary for Qualified Respondents | Respondent | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 5 | 6 | 8 | 9 | 10 | 13 | | | |
| 1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability? | In Devel-opment | No | In Devel-opment | Yes | No | Yes | Yes | | | |
| 2. Type of Facility? | Laboratory | Industrial | Laboratory | Office | Laboratory | Dormitory | Office & Industrial | | | |
| 3. What was the primary purpose in installing the intelligent features of the facility? | Other - Life Safety | Environ-mental, Funds Savings | Environ-mental, Automation & Security | Automation/ Service | Environ-mental, Automation | Funds Savings | Environ-mental, Automation & Sustainability | | | |
| 4. Status of the facility Design/Construction: | Just Completed | In Construction | In Construction | In Construction | In Construction | In Design | Facilities In Design, Constr & Just Completed | Mean | Median | Mode |
| 5. To what degree would you consider this facility as intelligent? | 5 | 4 | 5 | 4 | 4 | 5 | 5 | 4.57 | 5 | 5 |
| 6. To what degree was maintainability incorporated into the design process? | 5 | 3 | 5 | 3 | 3 | 4 | 5 | 4.00 | 4 | 3, 5 |
| 7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts? | 5 | 4 | 4 | 3 | 3 | 5 | 4 | 4.00 | 4 | 4 |
| 1. To what degree should future facility maintainability be incorporated into the intelligent building design process? | 5 | 4 | 4 | 5 | 4 | 4 | 5 | 4.43 | 4 | 4 |
| 2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process? | 5 | 4 | 4 | 5 | 3 | 5 | 5 | 4.43 | 4 | 4 |
| 3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)? | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 4.57 | 5 | 5 |

## 3.7. CHAPTER SUMMARY

In summary, Dinsmore encapsulates this topic as he writes regarding change in facilities specifically with reference to project management[46],

> Change is inevitable in our society, and it is clear that those organizations that refuse to adjust will fail to survive in the long run. In particular, if business, services, and government organizations are to survive, prosper, and meet the needs of their clients, they must plan for and implement change as a recognized part of the organizations' strategic plans. The individuals within the organizations must also be considered in any such change process. They must be provided with the time to accept the fact that the change is necessary, develop any new skills that may be required, and participate in the change being implemented.

Change is here, and is being driven by more and more competitiveness in the market. Furthermore, buildings are becoming more intelligent. Therefore, facility departments should plan strategically and perform tactically to meet their organizations' short and long-term objectives. This is accomplished by developing long-term master plans, incorporating maintenance audits and risk-based decision making models, to facilitate the daily decisions of the maintenance staff. And, facility managers and maintenance staffs alike must stay ahead of the power curve by staying abreast of the latest technological advances. This is accomplished through dedication to their profession and good training programs. When these methods are adhered to by an organization, tremendous monetary and customer service benefits can be realized.

## CHAPTER 4 – CONCLUSIONS AND RECOMMENDATIONS

It has been said that change is the only constant. This is extremely evident in the building and construction industries. Facilities have become so metamorphed and automated over the last few decades that past generations would be astounded. Smart buildings keep getting smarter. As a result, customer satisfaction and ROI's have increased. This is all possible because communication systems have improved, and talented individuals and organizations have recognized the need to establish open platforms that orchestrate multiple control systems from a holistic perspective. It is also because more efficient equipment and processes have been used to reduce utilityhorwit consumption.

Future smart building criteria will most likely focus more on biometric devices. Security will be a driving factor, requiring the incorporation of more voice recognition control systems, retina sensors, hand imprint systems, and possibly even DNA reading sensors. Smart materials, products and robotics will continue to be developed to further enhance personnel safety, worker productivity, and customer service type features. Most importantly, it is evident that all buildings will of necessity need to embrace smart building aspects due to competition in business. Therefore, the time has come to embrace new technology, honing in on its application and taking advantage of the benefits. Therefore, when future projects are initiated, architects and engineers should incorporate adequate pre-project planning into the process as it pertains to maintainability in order to reduce maintenance concerns and improve the respective organization's ROI. Then ultimately, when historians write about our generation, hopefully, it will be remembered by utilizing newly discovered technology in creative applications that laid the foundation for their artificially intelligent, automated facilities which then will be considered commonplace.

Some building industry hurdles are noted as they pertain to intelligent buildings and recommendations are provided for future study.

### 4.1. OPPORTUNITIES TO EXCEL

Proprietary information is tightly controlled and most manufacturers are not willing to share it. Though this is an impediment to total integration, it is quickly being overcome due to the role of the systems integrators who are familiar with multiple systems.

Existing proprietary equipment in the field discourages the use of integrated systems at this time. Some facility managers wish to keep their existing systems in use due to comfort and maintainability purposes.

Existing maintenance contracts with proprietary companies often prohibit systems integration, at least until their contracts have been fulfilled. However, until technology is proven and as systems are gradually changed out and maintenance contracts expire, integration will be hampered by existing contracts.

Some organizations fear to change from a proprietary source to another, due to costs associated with the change. Therefore, many times inadequate consideration is given to change providers.

Facilities utilizing the latest technology can be more susceptible to schedule delays. Horwitz stated in reference to Singapore's Capitol Tower project, "Another complexity was the fact that such a cutting-edge project demanded the latest technology – something that tends to be a moving target.[13]" Horwitz quoted a statement made by Peter Wan, who was a technical director for Parsons Brinckerhoff Consultants[13]. "At times, decisions had to be delayed in anticipation of a new emerging technology or to wait for an impending price drop for technology". Additionally utilizing emerging technologies, more time should be allotted for testing at the end of the project. Therefore, more preplanning and more difficulties should be anticipated which can significantly impact schedule driven projects.

Control systems packages are normally bid under separate contracts. This promulgates more proprietary systems while inhibiting the total integration of these systems. Horwitz states U.S. building and construction methodologies are not exactly conducive to integrated buildings [47]. For instance, the manner in which the Construction Specification Institute's [CSI] MasterFormat divides building systems into 16 separate divisions discourages integration because the mechanical, electrical, controls, and security systems will often be bid separately, notes EYP's Caloz [Jack Caloz, P. E., managing principal of EYP Mission Critical Facilities, New York][47].

"Everything tends to get broken apart," he says. Even though CSI is in the process of reorganizing the format to be more "integration-friendly," Caloz points out, "in the marketplace, there are many specialists in each of these areas, but not a lot of generalists."

New bidding processes with standard contract language should be explored to facilitate more controls integration.

One continuing impediment will be that of the actual security of the controls system itself. As new technology uses Internet systems, the susceptibility to hackers will always be present. Therefore, the latest fire-wall technology should be implemented as the risks of system corruption are too great. University of Maryland Baltimore County addressed this concern by setting up the critical buildings on their own systems located within each facility[48]. When hackers broke through and damaged much of the campus BAS system, the critical facilities were unaffected.

### 4.2. SUGGESTIONS FOR FUTURE ENDEAVORS

1. Plan ahead. With the rate at which technology is progressing, it is relatively certain that new techniques and products will be forthcoming. Innovative researchers continue to develop smart building materials and systems.

2. Use features that permit future technological modifications without much retrofit work. This would include under-floor wiring and ventilation aspects.

3. Design buildings holistically. Evaluate their end uses and apply as many technological initiatives as possible that best suit the facilities' purpose.

4. Do homework in deciding which technology to use. Do not necessarily continue with sole source providers without first investigating what other options are available on the market. Therefore, to be as effective as possible in today's competitive marketplace, continuous learning programs/efforts should be used to keep up with the latest changes.

5. Develop bid packages that enable systems integrators to put together creative packages.

6. Design with the end in mind. Never lose sight that smart buildings are for the benefit of the customers. Osment indicated that automation is about refining the human aspect while reducing the inefficiencies with the end result focused on improving customer service[49]. Smart buildings help accomplish this objective.

7. Capitalize upon technological advances in other industries and apply them to the facilities profession. One factor that may determine how quickly intelligent buildings develop globally is how effectively building and construction industries take advantage of advances made in other sectors, namely industrial and telecommunications. Horwitz offered to the construction industry the following recommendation[13]; "Typically there is a three- to five year time lag [adopting technology] from the process control/industrial sector to the building industry," notes Siemen's [Kevin] Osborn. But the whole idea is to avoid building a brand new protocol when it's possible to adopt existing protocols such as XML, Modbus and Ethernet.

8. Prepare for the unexpected. One lesson that 911 taught the world is to prepare for the unexpected. Develop contingency plans for as many potential scenarios as possible. This will help prevent many negative ramifications.

9. Prepare personnel for changes well in advance. Lobby and acquire funding for training to prepare the maintenance staff before any major changes occur. This should help better prepare them for the change, and should also help reduce the probability of costly mistakes or critical equipment failures.

10. Network for the best solutions. Benchmarking with other similar organizations can help sort out the prosperous ideas from the unprosperous ideas. Many larger metropolitan areas have benchmarking facility management groups for this purpose.

11. Look outside the box for additional ways to save funds by streamlining processes, reducing inefficiencies, and maximizing existing resources. For example, in the case of smaller organizations, this could include outlandish ideas such as partnering with sister firms in areas like co-negotiating contracts for training, janitorial services and

supplies procurement. This could help the smaller businesses to acquire economy in scale and quantity rebates. Larger firms even have more ways to save funds in utilities, operations and other areas. As organizations can save up to 35 percent of their operating budget[25], these savings could be applied to further maximizing their organizations' processes or added to the business' profit. In all of the aforementioned situations, the organization benefits from the savings and/or progression.

12. Organizations should always remember that though automation may be very important, the staff is the most important resource. Medlin states that it is the human aspect of organizations that is the valued possession[50].

13. Continue research in this area of study. As facility owners are looking closer at the facilities departments to contribute to the bottom line, facility managers should continue to investigate ways to significantly contribute to the mission.

## APPENDIX A

Copies of Informal Surveys Responses

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

**General Policy**

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☒ - Yes ☐ - In Development ☐ - No

**Specific Facility - Current Status**

2. Type of Facility?

☐ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☒ - Other

For "Other", please describe: Churches, Social Service Centers, Apartments, Retail Centers

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☐ - Other

For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☒ - In Design, ☐ - In Construction, ☐ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☒ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

**Future Status**

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

Respondent #1 Survey Response

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes ☐ - In Development ☒ - No

## Specific Facility - Current Status

2. Type of Facility?

☒ - Office, ☒ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other
For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☒ - Automation/Service, ☒ - Funds Savings, ☐ - Other
For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☐ - In Design, ☐ - In Construction, ☒ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Respondent #2 Survey Response

## Intelligent Buildings – Preplanning & Maintainability

### "Informal Survey"

Comments: Facility automation is critical to providing an efficient workspace and optimum work environment to support business and government functions. Facilities constructed without automated/intelligent features will have higher operating and maintenance cost and will experience significantly higher customer complaints.

Respondent # 2 Survey Comments

## Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

**General Policy**

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes ☒ - In Development ☐ - No

**Specific Facility - Current Status**

2. Type of Facility?

☐ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☒ - Other

For "Other", please describe: laboratories

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☐ - Automation/Service, ☐ - Funds Savings, ☒ - Other

For "Other", please describe: life safety

4. Status of the facility Design/Construction:

☐ - In Design, ☐ - In Construction, ☒ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

**Future Status**

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments:

Respondent #3 Survey Response

## Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

### General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☑ - Yes ☐ - In Development ☐ - No

### Specific Facility - Current Status

2. Type of Facility?

☐ - Office, ☑ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other

For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☐ - Automation/Service, ☑ - Funds Savings, ☐ - Other

For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☐ - In Design, ☐ - In Construction, ☐ - Just Completed, ☑ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☑ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☑ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☑ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

### Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☑ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☑ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☑ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

Respondent #4 Survey Response

# Intelligent Buildings – Preplanning & Maintainability
"Informal Survey"

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes  ☐ - In Development  ☒ - No

## Specific Facility - Current Status

2. Type of Facility?

☐ - Office, ☒ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other
For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☒ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☐ - Other
For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☐ - In Design, ☒ - In Construction, ☐ - Just Completed, ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

Respondent #5 Survey Response

## Intelligent Buildings – Preplanning & Maintainability
**"Informal Survey"**

**General Policy**

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes ☒ - In Development ☐ - No

**Specific Facility - Current Status**

2. Type of Facility?

☐ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other
For "Other", please describe: Laboratory

3. What was the primary purpose in installing the intelligent features of the facility?

☒ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☐ - Other
For "Other", please describe: Multiple Levels of Security

4. Status of the facility Design/Construction:

☐ - In Design, ☒ - In Construction, ☐ - Just Completed, ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

**Future Status**

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments:

Respondent #6 Survey Response

## Intelligent Buildings – Preplanning & Maintainability
**"Informal Survey"**

**General Policy**

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes ☒ - In Development ☐ - No

**Specific Facility - Current Status**

2. Type of Facility?

☐ - Office, ☒ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other
For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☐ - Other
For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☒ - In Design, ☐ - In Construction, ☐ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

**Future Status**

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

Respondent #7 Survey Response

## Intelligent Buildings – Preplanning & Maintainability
**"Informal Survey"**

**General Policy**

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☒ - Yes ☐ - In Development ☐ - No

**Specific Facility - Current Status**

2. Type of Facility?

☒ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other
For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☐ - Other
For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☐ - In Design, ☒ - In Construction, ☐ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

**Future Status**

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

Respondent #8 Survey Response

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☐ - Yes ☐ - In Development ☒ - No

## Specific Facility - Current Status

2. Type of Facility?

☐ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☒ - Other

For "Other", please describe: laboratory

3. What was the primary purpose in installing the intelligent features of the facility?

☒ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☐ - Other

For "Other", please describe:

4. Status of the facility Design/Construction:

☐ - In Design, ☒ - In Construction, ☐ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Respondent #9 Survey Response

## Intelligent Buildings – Preplanning & Maintainability

### "Informal Survey"

Comments: Our organization establishes core teams at the start of the design phase on each of our new building projects. These core teams are established to provide input into the design process from team members. These team members are key stakeholders for the project and include: in-house project manager, client(s) to be housed in the building, physical security, health and safety representative, operations and maintenance (O & M) representatives, among others. The O & M representatives bring to the table their expertise in Operations and Maintenace. They provide O & M input and also review design submittals during each phase of design to help ensure maintainability of building systems and components. Design standards have recently been published that provide guidelines for systems and components to be installed in new construction and renovation projects. These guidelines were developed with input and review of the O & M organization and are included as a requirement for A/E design. One area in which improvements might be made is in the area of metrics/benchmarking for O & M purposes, especially for key building systems. While this is done to some degree, there is not an on-going process for review and update. A drawback that is frequently faced by project managers is to provide suitable weight to life cycle cost factors when making design decisions. Most projects are heavily driven by the upfront costs which makes it more difficult to adequately consider long term cost impacts for certain decisions. An effective means for evaluating and quantifying the impact of key systems on future maintenance costs could help in the overall decision process for these systems. This could result in a lower cost of maintenance and operations due to selection of more cost-effective systems. It could also be used to better predict the cost of O & M maintenance and thus aid in the planning and budgeting for this activity. Finally, I believe another helpful tool would be the development of a Maintenance Master Plan (MMP) for each new building . This MMP would include an inventory of major equipment and systems.and their key components. In addition, the MMP would includea schedule for major overhaul and repair of these items with a projected cost in present day dollars. This would further aide in budget justifications and planning efforts for future O & M budgets and help to ensure critical systems were replaced or upgraded when needed.

**Respondent #9 Survey Comments**

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☒ - Yes ☐ - In Development ☐ - No

## Specific Facility - Current Status

2. Type of Facility?

☐ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☒ - Other
For "Other", please describe: Enlisted Personnel Dormitory

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☐ - Automation/Service, ☒ - Funds Savings, ☐ - Other
For "Other", please describe:

4. Status of the facility Design/Construction:

☒ - In Design, ☐ - In Construction, ☐ - Just Completed, ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Respondent #10 Survey Response

## Intelligent Buildings – Preplanning & Maintainability
### "Informal Survey"

Comments: The above mentioned Air Force renovation project will replace the entire HVAC systems in two, side-by-side 144 person dormitories on Hurlburt Field, using a hybrid geothermal central plant to provide chilled water to individual fan coil units in all the dorm rooms of both facilities. While the geothermal plant could also provide warm water for comfort heating, both of these dorms only have a two-pipe (conditioned water) HVAC system currently and it would be difficult (with limited above ceiling space and access), as well as very cost prohibitive to change over to a 4-pipe system which is now the Air Force standard. Since two-pipe systems are not "user friendly" (i.e., during seasonal change overs from cooling to heating and vice versa, occupants are often very uncomfortable and technicians frequently have to make several heat to cool to heat switches per season), we made a design decision to use small strip heaters at each fan coil unit for the heating season. The annual energy cost savings for this new hybrid geothermal HVAC system (even with the electric strip heaters) will more than pay for the construciton cost in only 8 years.

Respondent #10 Survey Comments

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☒ - Yes ☐ - In Development ☐ - No

## Specific Facility - Current Status

2. Type of Facility?

☒ - Office, ☒ - Industrial, ☐ - Retail, ☒ - Warehouse, ☒ - Other

For "Other", please describe: academic

3. What was the primary purpose in installing the intelligent features of the facility?

☐ - Environmental, ☒ - Automation/Service, ☒ - Funds Savings, ☐ - Other

For "Other", please describe:

4. Status of the facility Design/Construction:

☐ - In Design, ☐ - In Construction, ☐ - Just Completed, ☐ - Completed within 1-3 Yrs, ☒ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Respondent #11 Survey Response

## Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

Comments: We have been using design and construction standards to improve maintainability , increase energy savings and insure architectual compatability for a number of years. We also have used an energy management control system and have incorporated other systems such as occupancy sensors to control lights to help manage our energy costs.

Respondent #11 Survey Comments

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☒ - Yes ☐ - In Development ☐ - No

## Specific Facility - Current Status

2. Type of Facility?

☒ - Office, ☐ - Industrial, ☐ - Retail, ☐ - Warehouse, ☐ - Other
For "Other", please describe: ☐

3. What was the primary purpose in installing the intelligent features of the facility?

☒ - Environmental, ☐ - Automation/Service, ☒ - Funds Savings, ☐ - Other
For "Other", please describe: ☐

4. Status of the facility Design/Construction:

☐ - In Design, ☐ - In Construction, ☐ - Just Completed, ☐ - Completed within 1-3 Yrs, ☒ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☒ - Moderate, 4. ☐ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Comments: ☐

Respondent #12 Survey Response

# Intelligent Buildings – Preplanning & Maintainability

**"Informal Survey"**

## General Policy

1. Does the organization with which you are affiliated have design standards specifically oriented to facility maintainability?

☒ - Yes ☐ - In Development ☐ - No

## Specific Facility - Current Status

2. Type of Facility?

☒ - Office, ☒ - Industrial, ☐ - Retail, ☒ - Warehouse, ☐ - Other
For "Other", please describe: [ ]

3. What was the primary purpose in installing the intelligent features of the facility?

☒ - Environmental, ☒ - Automation/Service, ☐ - Funds Savings, ☒ - Other
For "Other", please describe: sustainability

4. Status of the facility Design/Construction:

☒ - In Design, ☒ - In Construction, ☒ - Just Completed. ☐ - Completed within 1-3 Yrs, ☐ - 3+ Yrs

5. To what degree would you consider this facility as intelligent?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

6. To what degree was maintainability incorporated into the design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

7. To the best of your knowledge, what degree of savings are expected and/or realized due to facility maintainability preplanning efforts?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☒ - Above Average, 5. ☐ - High

## Future Status

1. To what degree should future facility maintainability be incorporated into the intelligent building design process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

2. How important will it be for larger organizations (i.e. municipalities, educational systems, industrial complexes, etc.) to have established design standards that incorporate maintainability into the process?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

3. As facility automation and technology changes, to what degree will it affect maintenance staffs (i.e. education, training, staffing levels, etc.)?

1. ☐ - None, 2. ☐ - Little, 3. ☐ - Moderate, 4. ☐ - Above Average, 5. ☒ - High

Any additional comments, opinions and future recommendations that will facilitate this or future research are solicited and much appreciated. Please provide them below and/or on a following page.

Respondent #13 Survey Response

**Intelligent Buildings – Preplanning & Maintainability**

**"Informal Survey"**

Comments: All vertical construction in the Army Corps of Engineers will meet the LEEDs gold rating in FY 06

Respondent #13 Survey Comments

## APPENDIX B

### Professional Biographical Record for Richard A. Danks

Richard Danks is the Deputy Chief, Facilities Division at the NASA Glenn Research Center in Cleveland, Ohio. Mr. Danks is responsible for managing facilities operations, maintenance, facilities engineering, and construction, for the Center. Mr. Danks is a member, and past vice-chair, of the NASA Engineering and Construction Committee (ECIC), a member of the NASA Operations and Engineering Panel (OEP), and an instructor for the NASA CoF Management course and the NASA Sustainability course. He has performed facilities and maintenance program assessments for NASA, the Smithsonian Institution and the US Department of State. Mr. Danks has been with NASA since 1990.

Before joining NASA, Mr. Danks was employed for ten years at the Cleveland Clinic Foundation in Cleveland Ohio, and was responsible for managing the operation and maintenance of HVAC systems and other critical medical systems for this large, tertiary health care campus. Prior to that, Mr. Danks worked for the Gilbane Building Company (a construction management firm) in Cleveland, Ohio as a field superintendent and estimator working on health care facilities and automotive assembly plants. Also, Mr. Danks worked for the Austin Company, a design-build firm, as a mechanical engineer, estimator and field superintendent working on industrial, commercial and health care facilities.

Outside NASA, Mr. Danks is an active member of ASHRAE participating on Technical Committee 1.7 – Operation and Maintenance Management, Technical Committee 8.2 - Centrifugal Machines, Technical Committee 4.12 – Integrated Building Design. Mr. Danks is also a member of ASME.

He is active with the Construction Industry Institute (CII) and a past Chairman of Research Team 142 - Design and Construct for Maintainability and Chairman of Education Team 142, which developed an education module for design for maintainability. During this time he was principal author of two CII publications on design for maintainability. He is also a member of the CII Education Committee. Mr. Danks has also had a paper published in the Society for Machinery Failure Prevention Technology proceedings. In addition Mr. Danks has given numerous presentations at ASHRAE meetings, maintenance conferences, NASA conferences, and at the University of Wisconsin - School of Professional Development.

Mr. Danks graduated from Lafayette College in Easton, Pa. with a BSME, and has earned an MBA from Cleveland State University, Cleveland, Ohio. Mr. Danks is a registered Professional Engineer in Ohio and Pennsylvania and has a Third Class Stationary Engineer's License from Ohio.

Mr. Danks received the NASA Exceptional Service Medal in 2001, was named Federal Engineer of the Year for NASA by the National Society of Professional Engineers in 2000, and has been recognized by the Association of Facilities Engineers in 1997 for his maintenance work while at NASA.

Mr. Danks lives in Kirtland, Ohio with his wife and daughter.

02/09/04

# RICHARD J. INGENLOFF

## Summary of Professional Experience

Mr. Ingenloff has over 26 years of proven leadership in the engineering industry with extensive management experience in design/construction, facility plant operations, and environmental business areas to include strategic planning for capital investment. Highly successful leading large, diverse organizations; directing results driven project teams; formulating policy; and defining program objectives. Skilled in problem solving and troubleshooting with demonstrated ability to resolve complex organizational, technical, financial, and project delivery challenges. Reputation for systematic approach using management talents to create information flow, partnerships, and operating practices to deliver desired results. Air Force retired Colonel. Professional affiliations: Society of American Military Engineers and Chi Epsilon.

## Education

- Master of Science, Engineering Management, Air Force Institute of Technology, 1986
- Bachelor of Science, Civil Engineering, Texas A&M University, 1977

## Significant and Relevant Project Experience Within the Past Five Years

- **2002 – Present.** Senior Associate; Booz Allen Hamilton, San Antonio, Texas. Leads 40 staff professionals and regional infrastructure business supporting Air Force and other defense agencies. Directs a significant portion of Booz Allen's 5-year Global Engineering, Integration, and Technical Assistance (GEITA) contract with the Air Force Center for Environmental Excellence involving infrastructure, environmental, and housing privatization management. Provides leadership for management and growth of business activities as well as office governance.
- **2000 – 2002.** Chief, Engineering; Headquarters, US Air Force, Washington DC. Directed 20 program managers in developing and executing the Air Force Facility Acquisition Program--a $1.2B annual investment for 168 installations worldwide. Advocated and justified program priorities to Congress, and oversaw 602 ongoing construction projects totaling $4.6B. Built a $117M cost savings strategy to construct 316 projects worth $3B over a three year period.

Developed the 2002 Air Force Construction Program consisting of 162 projects totaling $1.52B--largest program approved by Congress in 11 years.

- **1998 – 2000.** Support Group Commander; Hickam Air Force Base, Hawaii. Installation "mayor" in-charge of 2,100 personnel supporting a Pacific en-route infrastructure base (2,100 facilities, 2,663 housing units, 22,000+ customers). Managed a $58M annual operating budget and the operations of civil engineering, security forces, communications, and morale/welfare services. Modernized base housing--459 whole-house upgrades and 1,121 kitchen/bath repairs for $103M; launched privatization initiative; innovative Family Helping Families self-help program won Presidential Service Award. Pivotal in base winning Presidential Installation Excellence Award.

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## Significant and Relevant Project Experience Beyond the Past Five Years

- **1996 – 1998.** Chief, Base Closure Restoration; Air Force Center for Environmental Excellence, Texas. Directed 45 engineers, environmental scientists, and construction inspectors responsible for the full spectrum of restoration activities from preliminary assessments to long term monitoring at 26 closure bases. Executed a $660M environmental cleanup program using 50 contracts to permit rapid land reuse through either deed transfers or long term leases.
- **1993 – 1995.** Base Civil Engineer; Whiteman Air Force Base, Missouri. Public Works Director in-charge of 459 personnel supporting the B-2 bomber/A-10 fighter beddowns and Minuteman II missile deactivation. Managed over $120M per year in facility operations, maintenance, and construction. Responsible for the care and operation of property to include land, 757 support facilities, 991 housing units, and utilities valued at $711M. Successfully fast-tracked a $35M design and construction program for 28 hangars, maintenance, and other support facilities to meet Congressionally mandated arrival date of 22 fighter aircraft. Accelerated deactivation of 165 ballistic missile launch facilities covering 10,000 square miles. Drove first-of-its-kind, state-approved site closure document meeting environmental regulatory requirements and US-Soviet treaty parameters.
- **1992 – 1993.** Base Civil Engineer; Homestead Air Force Base, Florida. Public Works Director for installation with a $756M plant replacement value. Among 18 key personnel who remained on base during Hurricane Andrew; led over 900 personnel from 39 bases in the follow-on herculean civil engineering recovery and humanitarian service effort. Awarded 25 emergency utility/facility repair and debris removal projects worth $10M; orchestrated the $152.7M installation redevelopment plan to meet rigid Congressional restraints. Unit won Secretary of Defense Special Recognition for Installation Excellence Award.
- **1989 – 1991.** Chief, Construction Management; Riyadh, Kingdom of Saudi Arabia. Led a team of 258 military and contractor engineers in executing a $1.2B construction program encompassing 192 facilities in support of the Royal Saudi Air Force air defense mission. Responsible for the efforts of 6,000 construction personnel at 57 sites spread over 700,000 square miles. Catalyst behind design review and award of a $95M contract to construct 31 communication site facilities; initiated an intense inspection process on five $47M command posts; and managed the completion of 12 $26M radar complexes on-time to meet equipment delivery dates. Provided combat engineering and contractor support during the Gulf War.
- **1977 – 1989.** Resource Management Chief for the Air Force Civil Engineer; Inspector General Team member; and base Construction Management Chief and Technical Design Engineer.

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## Employment History

- Senior Associate, Booz Allen Hamilton, San Antonio, Texas, 2002 – Present
- Engineering Chief, Headquarters Air Force, Washington DC, 2000 – 2002
- Support Group Commander, Hickam Air Force Base, Hawaii, 1998 – 2000
- Base Closure Restoration Chief, Air Force Center for Environmental Excellence, Texas, 1996 – 1998
- Base Civil Engineer, Whiteman Air Force Base, Missouri, 1993 – 1995
- Base Civil Engineer, Homestead Air Force Base, Florida, 1992 – 1993
- Construction Management Chief, Riyadh, Kingdom of Saudi Arabia, 1989 – 1991
- Resource Management Chief, Headquarters Air Force, Washington DC, 1986 – 1989
- Executive Officer, Headquarters Tactical Air Command, Langley Air Force Base, Virginia, 1983 – 1995
- Inspector General Team, Headquarters Tactical Air Command, Langley Air Force Base, Virginia, 1981 – 1983
- Construction Management Chief, Spangdahlem Air Base, Germany, 1979 – 1981
- Technal Design Engineer, Spangdahlem Air Base, Germany, 1977 – 1979

**BIOGRAPHY**

**FOR**

**JIM MAXWELL**

Jim Maxwell is the Director, Facilities Planning and Project Management Office (FPPMO) for the Centers for Disease Control and Prevention (CDC). This position reports to the Director, Facilities Planning and Management Office. Mr. Maxwell holds a Bachelor of Science degree in Industrial Engineering from the Georgia Institute of Technology. He has also taken graduate level management courses from the Georgia Institute of Technology. CDC has employed him for over 23 years. He has been in his present position for almost 4 years. In this position, Mr. Maxwell has primary responsibility for execution of CDC's Facilities Masterplan with regard to design and construction of new facilities. He manages a staff of about 28 architects, engineers and other technical/administrative positions in addition to several contract employees. Most of the design and construction work is completed using A/E and construction contractors. His office currently has under design or construction over 1 million gross square feet of laboratory and office space. This is in addition to the approximately 400,000 gross square feet of laboratory and laboratory support space constructed in the last 4 years under Mr. Maxwell's management. FPPMO is also responsible for oversight and management of CDC's Repair and Improvement budget. Prior to this position, Mr. Maxwell served as the Assistant Director, Maintenance Planning and Control for about 8 years. In this position, Mr. Maxwell had oversight responsibilities for the operations and maintenance of CDC Atlanta area owned facilities and also responsibility for the work flow management systems such as work order system and preventative maintenance system. Mr. Maxwell has received several Special Act of Service Awards during his employment with CDC. Mr. Maxwell's first professional job was working for Lockheed Aircraft Corporation as an aircraft specification engineer. He worked at Lockheed for about 2 ½ years.

**EDUCATION:** 1976, Georgia Institute of Technology, BS, Industrial Engineering

1977–1978, Georgia Institute of Technology Postgraduate Courses

BIO
DR. TERESA R. POHLMAN

Dr. Teresa R. Pohlman has over 23 years of extensive leadership experience managing all aspects of public and private sector environmental and infrastructure program and product development, including planning, budgeting, test and evaluation, operations, maintenance, and construction. Her background includes management positions with responsibility for $300 million to over $1 billion annual budgets for environmental, infrastructure, and facility maintenance programs.

At Headquarters Air Force, she was the Environmental Division Chief, and managed the Air Force's $1 Billion environmental program for all bases in the United States and overseas. She also served as a Program Manager with the Air Force Base Conversion Agency, for a $300 million program concerned with base closure and disposal issues. At the Naval Facilities Engineering Command Headquarters, she served as the Navy point of contact for environmental base closure issues, health and safety implications of environmental cleanup, and quality assurance aspects of the cleanup program pertaining to laboratory and field work.

**Prior to the Department of Defense, she worked for several defense contractors, on research and development projects. At Rockwell International and NASA, she managed and executed the installation and test of Orbiter Experiments on the Space Shuttle Columbia.**

Currently, Dr. Pohlman is the Team Leader for the Integrated Sustainability, Environmental, and Safety IPT at the Pentagon Renovation Office (PRO). She also coordinates the implementation strategy for force protection projects, added to the Pentagon Renovation Program as a result of the September attacks. For their outstanding efforts in sustainable construction, her Team recently won the Presidential Award for Leadership in Federal Energy Management, one of five awarded in the federal government.

**<u>EDUCATION:</u>**

2002- Doctorate in Environmental Management and Systems Engineering, George Washington University
2002 – Certified Level III Department of Defense Acquisition Professional in Program Management
2002 – Leadership in Energy and Environmental Design (LEED) Accredited Professional
2000 - Master of Science, National Resource Strategy, - Industrial College of the Armed Forces
1998 - Federal Executive Institute - Leadership for a Democratic Society
1998 – Office of the Secretary of Defense - Defense Leadership and Management Program
1993 - Master of Science, Management, Florida Institute of Technology, FL

1992 – Office of Personnel Management - Women's Executive Leadership Program
1979 - Bachelor of Science, Biomedical Engineering, Vanderbilt University, TN

BIOGRAPHY
FOR
RITA A. OBERLE, Ph.D., P.E.

Dr. Rita Oberle holds dual faculty appointments in the School of Civil and Environmental Engineering, College of Engineering and the Building Construction Program, College of Architecture. Dr. Oberle is the former Director, Facilities Planning and Management for the Centers of Disease Control and Prevention. As Director she planned and managed Master Planning; Real Property, government owned and leased; Capital Facilities Construction Management; Design and Construction; and Operations and Management for 26 campuses worldwide. She spearheaded the planning and programming for an unprecedented $1.4 billion construction masterplan for state of the art biosafety levels 4, 3+, and 2 laboratories, scientific support facilities, high rise office complexes, and renovation of 40-year old infrastructure. She was a key member of the CDC security team to evaluate and upgrade security for CDC facilities worldwide after the WTC and Pentagon disasters. In 2000, she was awarded the Bliss Medal for outstanding educator by the Society of American Military Engineers and in 1999, Engineer of the Year in Government by the All Metro-Atlanta Engineering Organizations. In 1997 she won the prestigious National Science Foundation Career Award and has been awarded multiple USAF/OSR Visiting Professor Grants. Dr. Oberle joined the faculty at Georgia Institute of Technology, School of Civil and Environmental Engineering in 1995 after completing a distinguished career with the USAF. She was the recipient of the Department of Defense Distinguished Civilian Service Award, the highest award given to a civilian in the Department of Defense; the Air Force Restoration Award for Individual Excellence; and the National Society of Professional Engineers, Federal Engineer of the Year Award. She is a registered Professional Engineer and a nationally Certified Cost Analyst. She is the coholder of patents on expert systems for construction and environmental cost engineering and modeling. Her research includes engineering modeling, cost engineering and scheduling, value engineering, automation and productivity, alternative acquisition strategies, conflict avoidance, construction programming, and public policies

## Col. "Stretch" Dunn

**Move to back?**

[Even though book publishing traditions place author biographies at the back, this summary includes short introductions so you have an early perspective for the authors as does an audience prior to a speaker's remarks.]

C.H. "Stretch" Dunn, Jr. (U.S. Army Retired), P.E. is a 1966 honor graduate of the United States Military Academy and has a Master's degree in Engineering from the University of Illinois. He completed the Stanford University Advanced Management Program and the Center for Creative Leadership. Stretch was named the Distinguished Graduate at the Army Command and General Staff College and a Fellow at the Army War College.

Col. Dunn served three infantry divisions, earned the Expert Infantryman Badge and four awards for bravery, including the Silver Star. His battlefield leadership was in Vietnam (1968-69). His interest in the warrior ethos led him to co-invent the Dunn-Kempf War Game that taught a generation of Army officers small unit war fighting techniques and led to his teaching tactics at the U.S. Military Academy. He headed a 1,000 soldier combat unit and a 3,000 person organization with 40 field offices in the Southeast U.S. and Latin America.

Following retirement after 26 years in America's Army, Stretch served 10 years in corporate America with BE&K, an international engineering and construction company. He contributed wherever the need was greatest, including strategic planning, benchmarking, service to the Construction Industry Institute, career development programs, business development, teaching, and executive coaching.

He serves as President of Dyson Leadership Institute, writes, and teaches seminars on "Professionalism Under Stress" and "Ethical Fitness." With David, he is also co-author of Ethical Fitness and a speaker for the Personal Leadership Association, the Institute's Leadership Lessons series, and Leadership in Engineering and Construction programs. Stretch is the 2003 recipient of the Johnny Johnson Loyalty Award for outstanding volunteer service to the Personal Leadership Association and the Institute. He serves on his West Point class board and several boards in the Birmingham Area.

## APPENDIX C

**PROJECT SCORE SHEET (UNWEIGHTED)**

| SECTION I - BASIS OF PROJECT DECISION | | | | | | | |
|---|---|---|---|---|---|---|---|
| CATEGORY<br>Element | Definition Level | | | | | | Score |
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| A. BUSINESS STRATEGY | | | | | | | |
| A1. Building Use | | | | | | | |
| A2. Business Justification | | | | | | | |
| A3. Business Plan | | | | | | | |
| A4. Economic Analysis | | | | | | | |
| A5. Facility Requirements | | | | | | | |
| A6. Future Expansion/Alteration Considerations | | | | | | | |
| A7. Site Selection Considerations | | | | | | | |
| A8. Project Objectives Statement | | | | | | | |
| | | | | | | | |
| B. OWNER PHILOSOPHIES | | | | | | | |
| B1. Reliability Philosophy | | | | | | | |
| B2. Maintenance Philosophy | | | | | | | |
| B3. Operating Philosophy | | | | | | | |
| B4. Design Philosophy | | | | | | | |
| | | | | | | | |
| C. PROJECT REQUIREMENTS | | | | | | | |
| C1. Value-Analysis Process | | | | | | | |
| C2. Project Design Criteria | | | | | | | |
| C3. Evaluation of Existing Facilities | | | | | | | |
| C4. Scope of Work Overview | | | | | | | |
| C5. Project Schedule | | | | | | | |
| C6. Project Cost Estimate | | | | | | | |
| | | | | | | | |

**Definition Levels**

**0 =Not Applicable** **2 =Minor Deficiencies** **4 =Major Deficiencies**
**1 =Complete Definition** **3 =Some Deficiencies** **5 =Incomplete or Poor Definition**

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| SECTION II - BASIS OF DESIGN | | | | | | | |
|---|---|---|---|---|---|---|---|
| CATEGORY<br>Element | Definition Level | | | | | | Score |
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| D. SITE INFORMATION | | | | | | | |
| D1. Site Layout | | | | | | | |
| D2. Site Surveys | | | | | | | |
| D3. Civil/Geotechnical Information | | | | | | | |
| D4. Governing Regulatory Requirements | | | | | | | |
| D5. Environmental Assessment | | | | | | | |
| D6. Utility Sources with Supply Conditions | | | | | | | |
| D7. Site Life Safety Considerations | | | | | | | |
| D8. Special Water and Waste Treatment Req'mts | | | | | | | |
| | | | | | | | |
| E. BUILDING PROGRAMMING | | | | | | | |
| E1. Program Statement | | | | | | | |
| E2. Building Summary Space List | | | | | | | |
| E3. Overall Adjacency Diagrams | | | | | | | |
| E4. Stacking Diagrams | | | | | | | |
| E5. Growth & Phased Development | | | | | | | |
| E6. Circulation and Open Space Requirements | | | | | | | |
| E7. Functional Relationship Diagrams/Room by Rm | | | | | | | |
| E8. Loading/Unloading/Storage Facilities Req'mts | | | | | | | |
| E9. Transportation Requirements | | | | | | | |
| E10. Building Finishes | | | | | | | |
| E11. Room Data Sheets | | | | | | | |
| E12. Furnishings, Equipment, & Built-Ins | | | | | | | |
| E13. Window Treatment | | | | | | | |
| | | | | | | | |

**Definition Levels**

**0 =Not Applicable** **2 =Minor Deficiencies** **4 =Major Deficiencies**
**1 =Complete Definition** **3 =Some Deficiencies** **5 =Incomplete or Poor Definition**

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CII Preplanning Un-weighted Worksheet Page 2

| SECTION II - BASIS OF DESIGN (continued) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CATEGORY<br>Element | Definition Level | | | | | | Score |
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| F. BUILDING/PROJECT DESIGN PARAMETERS | | | | | | | |
| F1. Civil/Site Design | | | | | | | |
| F2. Architectural Design | | | | | | | |
| F3. Structural Design | | | | | | | |
| F4. Mechanical Design | | | | | | | |
| F5. Electrical Design | | | | | | | |
| F6. Building Life Safety Requirements | | | | | | | |
| F7. Constructability Analysis | | | | | | | |
| F8. Technological Sophistication | | | | | | | |
| | | | | | | | |
| G. EQUIPMENT | | | | | | | |
| G1. Equipment List | | | | | | | |
| G2. Equipment Location Drawings | | | | | | | |
| G3. Equipment Utility Requirements | | | | | | | |
| | | | | | | | |

**Definition Levels**

**0 =Not Applicable** **2 =Minor Deficiencies** **4 =Major Deficiencies**
**1 =Complete Definition** **3 =Some Deficiencies** **5 =Incomplete or Poor Definition**



CII Preplanning Un-weighted Worksheet Page 3

| SECTION III - EXECUTION APPROACH | | | | | | | |
|---|---|---|---|---|---|---|---|
| CATEGORY<br>Element | Definition Level | | | | | | Score |
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| H. PROCUREMENT STRATEGY | | | | | | | |
| H1. Identify Long Lead/Critical Equip. & Mat'ls | | | | | | | |
| H2. Procurement Procedures and Plans | | | | | | | |
| | | | | | | | |
| J. DELIVERABLES | | | | | | | |
| J1. CADD/Model Requirements | | | | | | | |
| J2. Documentation/Deliverables | | | | | | | |
| | | | | | | | |
| K. PROJECT CONTROL | | | | | | | |
| K1. Project Quality Assurance and Control | | | | | | | |
| K2. Project Cost Control | | | | | | | |
| K3. Project Schedule Control | | | | | | | |
| K4. Risk Management | | | | | | | |
| K5. Safety Procedures | | | | | | | |
| | | | | | | | |
| L. PROJECT EXECUTION PLAN | | | | | | | |
| L1. Project Organization | | | | | | | |
| L2. Owner Approval Requirements | | | | | | | |
| L3. Project Delivery Method | | | | | | | |
| L4. Design/Construction Plan & Approach | | | | | | | |
| L5. Substantial Completion Requirements | | | | | | | |
| | | | | | | | |

**Definition Levels**

**0 =Not Applicable** **2 =Minor Deficiencies** **4 =Major Deficiencies**
**1 =Complete Definition** **3 =Some Deficiencies** **5 =Incomplete or Poor Definition**

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# APPENDIX D

## PROJECT SCORE SHEET (WEIGHTED)

| SECTION I - BASIS OF PROJECT DECISION | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Definition Level | | | | | | Score |
| CATEGORY<br>Element | 0 | 1 | 2 | 3 | 4 | 5 | |
| A. BUSINESS STRATEGY (Maximum = 214) | | | | | | | |
| A1. Building Use | 0 | 1 | 12 | 23 | 33 | 44 | |
| A2. Business Justification | 0 | 1 | 8 | 14 | 21 | 27 | |
| A3. Business Plan | 0 | 2 | 8 | 14 | 20 | 26 | |
| A4. Economic Analysis | 0 | 2 | 6 | 11 | 16 | 21 | |
| A5. Facility Requirements | 0 | 2 | 9 | 16 | 23 | 31 | |
| A6. Future Expansion/Alteration Considerations | 0 | 1 | 7 | 12 | 17 | 22 | |
| A7. Site Selection Considerations | 0 | 1 | 8 | 15 | 21 | 28 | |
| A8. Project Objectives Statement | 0 | 1 | 4 | 8 | 11 | 15 | |
| CATEGORY A TOTAL | | | | | | | |
| B. OWNER PHILOSOPHIES (Maximum = 68) | | | | | | | |
| B1. Reliability Philosophy | 0 | 1 | 5 | 10 | 14 | 18 | |
| B2. Maintenance Philosophy | 0 | 1 | 5 | 9 | 12 | 16 | |
| B3. Operating Philosophy | 0 | 1 | 5 | 8 | 12 | 15 | |
| B4. Design Philosophy | 0 | 1 | 6 | 10 | 14 | 19 | |
| CATEGORY B TOTAL | | | | | | | |
| C. PROJECT REQUIREMENTS (Maximum = 131) | | | | | | | |
| C1. Value-Analysis Process | 0 | 1 | 6 | 10 | 14 | 19 | |
| C2. Project Design Criteria | 0 | 1 | 7 | 13 | 18 | 24 | |
| C3. Evaluation of Existing Facilities | 0 | 2 | 7 | 13 | 19 | 24 | |
| C4. Scope of Work Overview | 0 | 1 | 5 | 9 | 13 | 17 | |
| C5. Project Schedule | 0 | 2 | 6 | 11 | 15 | 20 | |
| C6. Project Cost Estimate | 0 | 2 | 8 | 15 | 21 | 27 | |
| CATEGORY C TOTAL | | | | | | | |
| Section I Maximum Score = 413 | SECTION I TOTAL | | | | | | |

**Definition Levels**

**0 = Not Applicable** **2 = Minor Deficiencies** **4 = Major Deficiencies**
**1 = Complete Definition** **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**



CII Preplanning Weighted Worksheet Page 1

| SECTION II - BASIS OF DESIGN | | | | | | | |
|---|---|---|---|---|---|---|---|
| CATEGORY<br>Element | Definition Level | | | | | | Score |
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| D. SITE INFORMATION (Maximum = 108) | | | | | | | |
| D1. Site Layout | 0 | 1 | 4 | 7 | 10 | 14 | |
| D2. Site Surveys | 0 | 1 | 4 | 8 | 11 | 14 | |
| D3. Civil/Geotechnical Information | 0 | 2 | 6 | 10 | 14 | 19 | |
| D4. Governing Regulatory Requirements | 0 | 1 | 4 | 8 | 11 | 14 | |
| D5. Environmental Assessment | 0 | 1 | 5 | 9 | 12 | 16 | |
| D6. Utility Sources with Supply Conditions | 0 | 1 | 4 | 7 | 10 | 13 | |
| D7. Site Life Safety Considerations | 0 | 1 | 2 | 4 | 6 | 8 | |
| D8. Special Water and Waste Treatment Req'mts | 0 | 1 | 3 | 6 | 8 | 11 | |
| CATEGORY D TOTAL | | | | | | | |
| E. BUILDING PROGRAMMING (Maximum = 162) | | | | | | | |
| E1. Program Statement | 0 | 1 | 5 | 9 | 12 | 16 | |
| E2. Building Summary Space List | 0 | 1 | 6 | 11 | 16 | 21 | |
| E3. Overall Adjacency Diagrams | 0 | 1 | 3 | 6 | 8 | 10 | |
| E4. Stacking Diagrams | 0 | 1 | 4 | 7 | 10 | 13 | |
| E5. Growth & Phased Development | 0 | 1 | 5 | 8 | 12 | 15 | |
| E6. Circulation and Open Space Requirements | 0 | 1 | 4 | 7 | 10 | 13 | |
| E7. Functional Relationship Diagrams/Room by Room | 0 | 1 | 3 | 5 | 8 | 10 | |
| E8. Loading/Unloading/Storage Facilities Req'mts | 0 | 1 | 2 | 4 | 6 | 8 | |
| E9. Transportation Requirements | 0 | 1 | 3 | 5 | 7 | 9 | |
| E10. Building Finishes | 0 | 1 | 5 | 8 | 12 | 15 | |
| E11. Room Data Sheets | 0 | 1 | 4 | 7 | 10 | 13 | |
| E12. Furnishings, Equipment, & Built-Ins | 0 | 1 | 4 | 8 | 11 | 14 | |
| E13. Window Treatment | 0 | 0 | 2 | 3 | 4 | 5 | |
| CATEGORY E TOTAL | | | | | | | |

**Definition Levels**

**0 = Not Applicable**
**1 = Complete Definition**
**2 = Minor Deficiencies**
**3 = Some Deficiencies**
**4 = Major Deficiencies**
**5 = Incomplete or Poor Definition**



CII Preplanning Weighted Worksheet Page 2

| SECTION II - BASIS OF DESIGN (continued) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Definition Level | | | | | | |
| CATEGORY<br>Element | 0 | 1 | 2 | 3 | 4 | 5 | Score |
| F. BUILDING/PROJECT DESIGN PARAMETERS (Maximum = 122) | | | | | | | |
| F1. Civil/Site Design | 0 | 1 | 4 | 7 | 11 | 14 | |
| F2. Architectural Design | 0 | 1 | 7 | 12 | 17 | 22 | |
| F3. Structural Design | 0 | 1 | 5 | 9 | 14 | 18 | |
| F4. Mechanical Design | 0 | 2 | 6 | 11 | 15 | 20 | |
| F5. Electrical Design | 0 | 1 | 5 | 8 | 12 | 15 | |
| F6. Building Life Safety Requirements | 0 | 1 | 3 | 5 | 8 | 10 | |
| F7. Constructability Analysis | 0 | 1 | 4 | 8 | 11 | 14 | |
| F8. Technological Sophistication | 0 | 1 | 3 | 5 | 7 | 9 | |
| CATEGORY F TOTAL | | | | | | | |
| G. EQUIPMENT (Maximum = 36) | | | | | | | |
| G1. Equipment List | 0 | 1 | 5 | 8 | 12 | 15 | |
| G2. Equipment Location Drawings | 0 | 1 | 3 | 5 | 8 | 10 | |
| G3. Equipment Utility Requirements | 0 | 1 | 4 | 6 | 9 | 11 | |
| CATEGORY G TOTAL | | | | | | | |
| **Section II Maximum Score = 428** | | | | **SECTION II TOTAL** | | | |

**Definition Levels**

**0 = Not Applicable**
**1 = Complete Definition**
**2 = Minor Deficiencies**
**3 = Some Deficiencies**
**4 = Major Deficiencies**
**5 = Incomplete or Poor Definition**



CII Preplanning Weighted Worksheet Page 3

| SECTION III - EXECUTION APPROACH | | | | | | | |
|---|---|---|---|---|---|---|---|
| CATEGORY<br>Element | Definition Level | | | | | | Score |
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| H. PROCUREMENT STRATEGY (Maximum = 25) | | | | | | | |
| H1. Identify Long Lead/Critical Equip. & Materials | 0 | 1 | 4 | 7 | 10 | 14 | |
| H2. Procurement Procedures and Plans | 0 | 1 | 3 | 6 | 9 | 11 | |
| | | | | | | CATEGORY H TOTAL | |
| J. DELIVERABLES (Maximum = 11) | | | | | | | |
| J1. CADD/Model Requirements | 0 | 0 | 1 | 2 | 3 | 4 | |
| J2. Documentation/Deliverables | 0 | 1 | 2 | 4 | 6 | 7 | |
| | | | | | | CATEGORY J TOTAL | |
| K. PROJECT CONTROL (Maximum = 63) | | | | | | | |
| K1. Project Quality Assurance and Control | 0 | 1 | 3 | 4 | 6 | 8 | |
| K2. Project Cost Control | 0 | 1 | 4 | 7 | 10 | 13 | |
| K3. Project Schedule Control | 0 | 1 | 4 | 8 | 11 | 14 | |
| K4. Risk Management | 0 | 1 | 6 | 10 | 14 | 18 | |
| K5. Safety Procedures | 0 | 1 | 3 | 5 | 7 | 9 | |
| | | | | | | CATEGORY K TOTAL | |
| L. PROJECT EXECUTION PLAN (Maximum = 60) | | | | | | | |
| L1. Project Organization | 0 | 1 | 3 | 5 | 8 | 10 | |
| L2. Owner Approval Requirements | 0 | 1 | 4 | 6 | 9 | 11 | |
| L3. Project Delivery Method | 0 | 1 | 5 | 8 | 12 | 15 | |
| L4. Design/Construction Plan & Approach | 0 | 1 | 4 | 8 | 11 | 15 | |
| L5. Substantial Completion Requirements | 0 | 1 | 3 | 5 | 7 | 9 | |
| | | | | | | CATEGORY L TOTAL | |
| **Section III Maximum Score = 159** | | | | | | **SECTION III TOTAL** | |

**PDRI TOTAL SCORE**

**(Maximum Score = 1000)**

**Definition Levels**

**0 = Not Applicable**   **2 = Minor Deficiencies**   **4 = Major Deficiencies**
**1 = Complete Definition**   **3 = Some Deficiencies**   **5 = Incomplete or Poor Definition**

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