MENTORS One engineer discusses the new discipline of building commissioning, and another offers a primer for new project architects.

ARCHITECTURAL RECORD asked David Houghton, P.E., to discuss a new trend, building commissioning, which helps ensure that new buildings work as intended.

There’s a lot of talk these days about building commissioning. What is it? Like evaluating a ship’s seaworthiness before it sails, the commissioning process thoroughly inspects and aggressively tests commercial and institutional buildings to see that their systems are functioning well. Commissioning ensures that buyers get buildings that actually work—a feat that grows more difficult each year as increasingly complex systems seem to invite error into every phase of project development.

Systems that benefit from commissioning include HVAC, lighting, building automation, energy management, fire protection, security, and communications. Although saving energy isn’t always the primary goal of commissioning, it is often a very tangible benefit. New buildings are not always commissioned. In many cases, the owner and the design team rely on contractors to determine that they’ve met the specifications for system operation. But this method doesn’t always produce the desired results. Construction managers tend to pay more attention to budgets, schedules, and materials than the intricacies of building controls; inspectors are mostly concerned with life-safety issues; and designers are usually knee-deep in their next projects by the time final punch lists are being tackled.

Who does commissioning, and how much does it cost? A new breed of specialists, known as commissioning coordinators, is helping bring major construction projects to successful completion. These people, often former facility operators or controls contractors, tend to be good communicators with a broad knowledge of building systems. Rather than cast blame, they try to improve everyone’s understanding of how things are supposed to work and who is responsible for what. (Getting people to work together can be as challenging as getting equipment to work together.) Over the past several years, building commissioning has become a small but established industry with its own annual conferences and an emerging professional association.

Commissioning coordinators begin their work in the design phase, verifying that the design team’s intent is clearly communicated to the builders. They develop tests to put the building through its paces and make sure contractors know that final payments depend on passing them. They oversee the tests and certify that everything works—or help solve the problems that arise. Finally, commissioning coordinators help prepare accurate operation and maintenance documents and train building operators.

Commissioning costs upwards of $1 per square foot, depending on a building’s size and complexity. Energy savings often quickly recover the cost, and there are the added benefits of happy occupants, reduced maintenance costs, and averted haggling and finger-pointing.

In a recently constructed commercial building, the mechanical engineer specified a variable-speed drive for a large supply fan. The owner paid several thousand dollars for the device, which performs better and costs less to operate than constant-speed fans. The contractor installed it and claimed it was working properly—after all, the fan blew air, and the LEDs on the drive panel blinked convincingly.

However, when commissioning agents measured the fan’s input and output, they discovered that it was running 24 hours a day. They looked into the problem and found a simple programming error. A quick fix enabled the drive to do its job, but without the scrutiny of commissioning, the problem might have gone undetected for years and wasted the owner’s investment.

Can existing buildings be commissioned? Yes, although it’s harder to investigate systems that have been modified over the years. Even so, a recent study of 44 buildings showed that commissioning existing buildings cost 5 to 40 cents per square foot and usually resulted in energy savings that repaid the commissioning costs in less than a year.

Although the intricacies of mechanical, electrical, and communications systems are the domain of engineering specialists, the architect has overall responsibility for the owner’s interests in a successful project. In a world where projects are ever more complex and flawless operation is the exception rather than the rule, commissioning is a welcome antidote for Murphy’s law.

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ARCHITECTURAL RECORD asked Andy Covington, P.E., to share some of the basic questions that new project architects should address with consulting engineers during a project’s planning phase.

A project architect who is new to his or her role and blindly relies on mechanical, electrical, and plumbing (MEP) consulting engineers is looking for a career of grief and misery. As a new project architect, you should be prepared to answer a few basic questions in order to give consultants the guidance they need to do their jobs well.

What is the project’s engineering budget? It is all too common for architects to issue construction documents on a project only to have all bids come in over budget. Not only is this embarrassing, but it can also consume your profit. Once they know the budget, your engineers should be able to tell you what your options are based on conceptual architectural plans. It is better to find out that you will have to specify synthetic countertops instead of Italian marble as soon as possible rather than after you have shown the owner the marble samples. Otherwise, you may be forced to ask your client to choose between Italian marble and air-conditioning, which would be awkward late in the game.

The budget should be determined early and discussed often. At every design submittal, costs should be reviewed for accuracy to allow for adjustments should budgets creep over the original allocations.

What space do you have available for MEP equipment? One of your biggest tasks as an architect is to provide the owner with the maximum amount of usable space per unit area of construction. Based on the type of building under design and the area of the building, your engineers should be able to tell you how much space the electrical, mechanical, plumbing, and fire protection equipment will require.

Electrical engineers do not place their large gray panels at whim. The National Electrical Code requires a certain amount of clearance around these panels for the safety of maintenance personnel, a fact that is often overlooked by younger, inexperienced architects. While the finished design may vary from initial calculations (the clearances may vary depending on the panel ratings), the engineers should be able to estimate, early in the design, how many panels will be needed and what clearances each one will require.

Most architects don’t want to have to move walls late in the design process to accommodate mechanical equipment, especially after the majority of the space has been allocated to some other function. It would also be unacceptable to place plumbing vent stacks in the middle of second-story executive offices. Find out as early as possible how much space you’ll need for your engineering systems up front so that you can accommodate them on the first try.

What type of fixtures do you wish to use? Engineers and architects tend to view the design process from different perspectives, with the engineer placing a premium on functionality rather than aesthetics. Standard fixtures that MEP engineers select include luminaires, plumbing fixtures, plumbing actuation devices (handles, buttons, and electronic sensors), and heating, ventilation, and air-conditioning diffusers. Give your engineers some guidance in selecting equipment that will enhance, not detract from, the architectural mood of each space.

When lighting is a key issue on a project, seek out the services of a lighting designer with architectural training who is capable of meeting your functional and aesthetic lighting requirements. Don’t expect the average electrical engineer to (continued on page 356)
know what light fixtures will complement, say, your Romanesque design. Instead, tell the engineer what a fixture should look and point out the parts of the room you wish to accent with light. Do take advantage of the lighting engineer’s expertise, however; it may lead to design innovations.

What auxiliary systems are included in the design? Expect to hear this question most often from your electrical engineering consultant, whose purview is, basically, lighting and power systems. Electrical engineers sometimes work with fire-alarm systems, but they are installed by their providers in many instances. Auxiliary systems that may or may not be handled by your electrical engineering consultant include security, cable television, intercom and public address, time and bell control, telephone and data, video projection, and even nurse call systems.

Most electrical consultants can design these systems if necessary, especially if the building owner wishes to have them tested before the general contractor leaves the site. However, if the systems are installed during construction, the electrical subcontractor is likely to contract with the provider-installer (and attach his own profit margin), thereby increasing costs.

What energy sources are available? Does the owner have a preference? As long as electricity, oil, and natural gas (or propane) are provided by different companies, there will be disagreement as to which fuel to use. Your mechanical engineering consultant should be able to provide you with figures on which is more economical in both the short term and the long term. The choice is more often dictated by owner preference than by economics. Whatever energy source you go with, it’s imperative to make the decision early, as its delivery system will greatly influence a project’s design.

What special equipment will be in the building? Who will furnish it? Building owners and engineers generally manage to plan well for the basics. However, some kinds of equipment—such as wastewater-treatment systems, special ovens or ranges, vending machines, sensitive electronic devices, and other unusual machinery—are more likely than others to be overlooked in the early phases of the design process.

It may sound obvious, but cooking equipment should be designated during the schematic phase. Coffee makers and vending machines often require water connections and always require electricity, as do refrigerators, freezers, and automatic ice makers. Automatic ice makers always require water connections.

Your engineering consultants need as much information as possible to design appropriate systems. If you can’t provide the answers, point them to someone who can.

Now that you know what kinds of information your consultants will be seeking, you should be able to get the most out of preliminary project meetings. The earlier you address these issues, the quicker your engineers can provide you with contract documents that meet your expectations.

As a project architect, you are often responsible for coordinating the work of all design disciplines, and you are the individual that the owner holds responsible for the project’s success. Be sure that you and your engineers are asking the right questions.

Questions: If you have a question about your career, professional ethics, the law, or any other facet of architecture, design, and construction, please send submissions by mail to Mentors, Architectural Record, 1221 Avenue of the Americas, New York, N.Y. 10020; by fax to 212/512-4256; or by E-mail to sera@mcgraw-hill.com. Submissions may be edited for space and clarity.

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Building Commissioning

A new delivery method for ensuring successful building performance gains ground.

From Washington state to Florida, large institutional and government owners have grown disenchanted with their new buildings. Complaints over unexpectedly high energy costs, poor indoor air quality, and faulty lighting sensors are just a few of the operational problems that commonly surface after tenants move in. Correcting these deficiencies, however minor, becomes a much more complicated and costly task once the walls have been sealed, the occupants settled, and the design and construction teams paid and focused on other jobs. Realizing that an ounce of prevention is worth a pound of cure, many seasoned clients and practitioners have embarked on a project delivery process called “building commissioning.” The term, borrowed from naval jargon to describe the thorough preparation of a ship for battle, describes a still-evolving methodology that ensures a new building will function as well as intended.

Essentially, building commissioning refers to a methodical process in which the owner clearly stipulates the goals of the project in a written program of requirements; the architect describes how these will be met in a statement of design intent; and all aspects of a building are designed, installed, reviewed, operated, and maintained according to a thorough, written plan. The basic methodology first appeared in the construction industry during the 1980s with HVAC systems because most start-up problems are associated with this equipment. More recently, in recognition of the integrated nature of today’s architecture, the method has evolved into whole-building commissioning, in which virtually all specified components and systems are tested, from a mock-up of the building envelope to mechanical, lighting, elevator, and fire-safety systems.

Building commissioning tries to replicate in the architectural profession what total quality management achieves in the automotive industry, where a systematic program of development and testing ensures that a car runs well the first time it rolls off the lot, and the owners are equipped with a maintenance manual to keep it that way. One big difference between a car and a building, of course, is that the car is mass-produced from a single prototype, while each building is a prototype unto itself. A building commissioning program, therefore, must be
Parameters established during programming become the framework for the commissioning plan, which orchestrates the entire process. The plan spells out the intentions, becoming more detailed as the project develops.

custom-tailored to a specific project to reflect the needs of the client, site, program, design, and other unique conditions.

Proponents argue that such a rigorous process of quality assurance has become necessary because architecture has become so technically complex. Today’s buildings, explains Bertrand Ward, manager of technical services at the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) in Atlanta, “have more wiring and ductwork than a spacecraft.” Sophisticated computer systems and sensors must be precisely tuned, in conjunction with the building’s envelope, to achieve the energy efficiency, air quality, and other performance criteria increasingly demanded by government regulations and educated clients.

But changes in technology, and how these terms interact dynamically with one another, are the only driving forces behind building commissioning. In the design and construction industry, which suffers from increasingly shorter delivery times, ever smaller profit margins, and a generally litigious atmosphere, any project will gain from better communications between project team members, one of the hallmarks of building commissioning.

Commissioning agent
Building commissioning spans the entire life of a project. Its recommended tasks and documentation are divided into several phases: programming, design, construction, acceptance, and occupancy. In the programming phase, the client must make clear the intentions to have the new building commissioned, understanding its associated financial ramifications and scheduling demands.

A commissioning agent is then designated to coordinate the process. This agent can be appointed from the client’s own facilities management staff or the architect’s design team, or be hired as an outside consultant. The coordinator can even change during the project, with a member of the design team functioning as the commissioning agent during programming and design and the general contractor taking over during construction. Because a mechanical system is the most frequently tested building component, professionals trained in mechanical engineering have historically served this function. But as whole-building commissioning increases, a handful of architects are beginning to shoulder the responsibility.

At this stage, the owner puts in writing the program requirements based on a realistic budget; the design team defines the project’s basic criteria, such as quality of materials or environmental goals, and proposes how these will be met; and the commissioning agent begins to sketch out the scope, responsibilities, and schedule—for example, which building components and systems will be tested; who will write the specifications for such tests; in what sequence the tests will be undertaken and by whom; who will witness and verify the testing process; and how the test results should be reported.

Plan as living document
By setting criteria up front, explains Elia M. Sterling, president of Theodor D. Sterling and Associates, an interdisciplinary research and design firm in Vancouver, “the client and the design team understand the ground rules.” It is against these specific requirements that the building will ultimately be tested.

The parameters established during programming become the framework for the commissioning plan, which orchestrates the entire process. “The plan is a living document,” explains architect and engineer Charles Eley, president of Eley Associates, an architecture and engineering firm in San Francisco. It spells out the intentions of the project from the beginning, but becomes more detailed as the project develops.

During the next phase, the design is developed and construction documents are prepared. Architect and consultants further elaborate on the criteria—specifying, for example, the exact R-value for an exterior wall,
Commissioning Plan for a Lighting System

Lighting System Overview

Skylight Louver Operation

The LCM 3000 has a three-position switch on the face, marked Photo, Summer, and Winter.

Photocell mode

When the system is in the photocell mode of operation, the position of the skylight louver is continuously adjusted to maintain the maximum daylight illumination criteria of 75 fc. When daylight illumination level falls below 75 fc on the work surface, the louver will be fully open to allow the maximum amount of daylight into the space. The skylight louver automatically go into the photocell mode from the following signals:

a. Time of day signal from building management system.

b. After-hours use of the HVAC system.

c. Occupancy sensor signal within any skylight daylit area.

Summer mode

The summer mode is not used in this building because the skylight louver system is tied to the occupancy sensors to automatically close the louver after hours. As such, the summer mode has been deactivated; the switch defaults to the photocell mode of operation when placed in this position.

Optional winter setting

When the switch is set in the winter position, the louver will go to the fully open position if the building management system signals the LCM 3000 that the outside air temperature is low enough to keep the building cooled with outside air only.

Installation Inspection Plan

Skyline component shop drawings

Equipment inspection

2 Electrical lighting system components

Equipment inspection checklist

1 Natural lighting system

Louver close when building is unoccupied

Override closing of the louvers

Optional winter setting

Perimeter venetian blind adjustment

1 Daylight louver system

Lighting System Overview

Installation Inspection Plan

Functional Performance Test Plan

1. On a cloudless day between 10 am and 2 pm, turn the adjustment knob clockwise to fully open the louver.

2. Make sure the 2' x 4' fluorescent lights in the open office area are off.

3. In the open office zone, take four light readings at desk height as shown on verification form. Take the average and find a spot between the points where the light level equals that average. Use the reading at that point to calibrate the daylight level.

4. In managers' offices and reception zone, take one measurement on the desk of the assistant manager's office that has the photocell in the skylight well. Adjust window blinds to an angle of 15° with no direct sun entering the office.

5. Read the light meter at the selected location while the knob on the face of the LCM 3000 is gradually turned counterclockwise. Louvers will move in a closing direction. Stop turning the knob when the illumination is reduced to the desired level, at which time the green LED on the LCM 3000 will go dark. Temporarily mark this position on the face plate with a pencil.

6. To increase the illumination, turn the knob slowly clockwise to open the louvers until the desired illumination is achieved. If there is sufficient daylight and the louvers are not stopped against the limit switch, the red LED will go dark. Temporarily mark this position.

7. When the desired illumination is reached and neither LED is on, mark the face plate with a punch mark halfway between the two points. This will be the calibration setpoint.

Recommissioning Test Plan

1 General

2 Skylight louver system

Louver photocell recalibration

Louver close when building is unoccupied

Perimeter venetian blind adjustment

3 Electrical lighting system controls

Area occupancy sensors

Dimming photocells

Off-override photocells

Timeclock / Exterior photocell

Task lighting occupancy sensors

Skyline Installation Checklist

(27) 4.5' x 3.5' skylights in:

Open office area (20)

Managers' offices (2)

Lunchroom (1)

Reception area (2)

Cashier's area (2)

(2) 4.5' x 1.75' skylights in the open office

(4) 2' x 8' skylights in:

Carport (2)

Bathrooms (2)

Skylight louvers

Dampers

Controls

LCM 3000 controllers (2)

Daylight photosensors (2)

Comments:

Verifier name Signature Date

Skyline Louver Calibration - Open Office Zone 1

Date:__ Time:_ Outdoor Light Level:___ fc

Sky Condition: Clear__ Partly Cloudy__ Other

Initial Reading (fc) Adjustment 1 2 3

Point 1

Point 2

Point 3

Point 4

Total

Ave

Take initial readings and obtain average value. Find a point along diagonal with same value. Use this point for calibration. Tune system and record final setting above. Final average value should be between 60 and 75 fc.

Comments:

Verifier name Signature Date
Supporters of building commissioning contend that the benefits outweigh the added expense. Change orders are reduced, and energy is saved. Cost/benefit analyses that everyone can agree on have yet to be developed.

Supporters of building commissioning contend that the benefits far outweigh the added expense. Change orders and litigious claims are reduced during construction, energy is saved, and productivity of building occupants improves. Although their arguments are intuitively sound, researchers in the field have yet to develop cost/benefit analyses that everyone can agree on. Reasons for this include the fact that the process is in its infancy, and its scope and procedures vary among practitioners. According to PECI, even data collection and reporting methods differ among researchers.

Quantifying benefits
Nonetheless, many researchers, particularly in utility companies, are trying to quantify the costs and savings. They believe commissioning is one way of ensuring that energy-efficiency measures are installed correctly so that energy savings are realized.

In one such ongoing energy study by Southern California Edison (SCE) of seven existing Southern California buildings, researchers in the Technical and Design Services Department are trying to determine what the scope of commissioning should be—which tests and corrections yield a significant payback and which approach the point of diminishing returns (facing page). To date, they have found the payback period for correcting sample deficiencies, such as fixing economizer and pump controls, range from one year to just over four years. Christie Kjellman, project engineer at SCE, is quick to note that savings estimates will be greater once the other repairs are included in their calculations. Kjellman explains that other nonenergy benefits, such as extending equipment life and improving air quality, were not tallied into these numbers.

Although building commissioning is still in its infancy and a definitive approach has yet to be codified, several resources are available. For more information, call PECI at (503) 248-4636.—Nancy B. Solomon
The estimated payback period for repairing selected deficiencies ranges from one year to just over four years. Savings will be greater once the repairs for other energy-related deficiencies are included in the calculations. Researchers are currently applying DOE-2, a popular energy-estimating software, to generate a more detailed analysis of the study.