



PDHonline Course C740 (5 PDH)

Total Building Commissioning

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Total Building Commissioning

Part 1 – Commissioning Defined

Commissioning: a quality process for achieving, validating and documenting that the facility and its systems are planned, designed, installed, tested and capable of being operated and maintained to perform in conformity with the design intent. The process extends through all phases of a new or renovation project, from conceptualization to occupancy and operation, with checks at each stage of the process to ensure validation of their performance to meet the owner's design requirements.

Commissioning is a QA/QC (Quality Assurance / Quality Control) process that focuses on how building components and systems interact with each other. This integrated approach will reduce the potential for poor building performance since it will look at how the building systems and functions interact with one another. These systems, if testing separately may meet their individual objectives, but may optimize overall building performance.

Why Commissioning Now

What in the world is happening to the design profession?

- A while ago, doctors were asking the same question of their profession...What in the world is happening to the medical profession?
- HMOs were created to manage today's complex nature of health care and have effectively subordinated the profession of the medical doctor.
- Is building commissioning a similar movement in construction?

The changing role of the designer

- Webster's defines an architect as: a person who designs buildings and supervises their construction.
- Today, architects design buildings and have all but eliminated their role during construction.
- The architect's construction role has gone from supervision to inspection to observation.

- Now, the commissioning process which is a method to make sure the design intent if being met can be viewed as an infringement on the architect's role in design.

Liability Protection, Complexity & Money

- Liability protection has driven the architect out of their valuable role during construction.
- The complex nature of today's building technology may drive architecture to become a group of specialists who are experts in specific areas. This will further reduce overall design liabilities.
- Money: the cost of operation has grown faster than fees. Architects can no longer afford to give their clients the service they expect and deserve.

The Commissioning of Architecture

One frustrated architect recently suggested that we need to "Commission" our own profession back into a leadership role.

- We can no longer ignore the role of building commissioning in our profession.
- Building commissioning is a growing industry that more and more clients are seeing as a necessary part of the design process.
- One option might be to incorporate it into our menu of additional services.

And so we have come full circle from an era when the designer played an active role in every phase of a building's creation and development to one where the designer is being solicited to perform this same active role through the process of commissioning. The driving force behind this trend is as it always will be is economics. Owners have spent decades micro-managing the economics of the individual pieces and parts of a building's life cycle only to discover that the sum of their efforts have created a deleterious economic outcome. Here are some examples of how these good intentions gone badly:

- Minimizing the amount of time spent on a project by the designer to reduce the higher hourly fee cost.
- Opening up the bid process to more competitors in order to achieve lower construction cost.

- All but eliminating the time the designer spends following the construction of a project in the field in order to reduce higher fee cost.
- Placing third party monitoring within the construction contract in order to reduce the cost associated with multiple parties and contracts on a project.
- Shifting as much liability as possible to contracted parties in order to reduce the liability of the owner.
- Not spending enough money on the training of it operation and maintenance personnel in order to reduce non-productive payroll cost.
- Performing monitoring and analysis of building performance in-house or not at all in order to reduce the O&M budget.
- Etc.

All of the items listed above and many more not listed undoubtedly save money on an individual basis. However, when you step back and look at the big picture, which always forces you to considered life cycling to some degree, you realize that these individual decisions usually end up increasing the overall cost of building performance.

Many building owners are coming to realize the impact of their unsuccessful efforts to save money and are turning to commissioning as a solution. Commissioning has experienced favorable success since the process always places a priority on the big picture over individual decisions.

Power Plant Startup

The best example of modern day commissioning from my experience with the power plant construction industry is the process of startup. Power plant startup functions are performed by a separate group called the startup group. The end-goal of this startup group is to successfully start up the power plant such that the plant produces the designed amount of power for the owner. The startup group was always the last group of people on the project in a long list of personnel assigned that covered several years of effort on a full service EPC (Engineering, Procurement, and Construction) project. They were the only ones left in the face of the owner to answer all outstanding questions, complete all outstanding activities, diagnose all problems with the operational plant, repair all defects, and train the owner how to successfully operate the power plant. This was a huge assignment and undertaking to say the least.

Over the course of the project, however, these startup people always seemed to hanging around, attending meetings, posing questions that seemed far off in the future and sometimes just being a disruptive pain during the heat of project execution. Everyone else on the project had what seemed at the time more important objectives than the startup group. Here are some of the non-startup activities that the startup group was involved with over the course of the project.

1. Providing input to power plant proposals, reviewing the scope of services and contributing the development of the overall project schedule all prior to winning the project.
2. Reviewing the very first engineering work product which where the flow diagrams of the various power plant systems providing comments to the engineering group.
3. They really seemed to get excited when the P&ID (Piping and Instrumentation Diagrams) were developed. They seemed to have a lot to say about valving and control configurations associated with the various systems.
4. When the physical drawings were issued for comment that had great concern about valve and control locations as well as electrical panel and switchgear placement issues.
5. They continued their comprehensive review of the design as construction drawings were being issued.
6. They worked closely with the procurement division to get their input heard regarding selection of all manner of power plant purchases.
7. Every time there was a change issued in the design of any system they were there to give their comments on the impacts to plant operation.
8. They were involved with the construction team formation providing their input and recommendations regarding personnel and procedures.
9. When the construction team hit the field they were there in full force as one of the team groups participating in site set up, especially warehousing of permanent plant material and components.
10. Over the course of construction the startup group attended all progress meetings internally and with the client.
11. They were constantly in the field reviewing the installation of everything.
12. Whenever a change notice was issue by the construction group, they reviewed the fix and provided their input primarily regarding the operation of the plant.
13. They provided input to the development of construction quality assurance procedures.

14. They reviewed all of the testing that was performed during construction by the QC group.
15. As construction began to peak and head toward the finish line, the startup group finally began to perform their named function, that being the checkout, testing and startup of plant systems.
16. During the startup phase of the project, the startup group was constantly initiating changes and repairs that were necessary to tweak the various operational functions of the plant.
17. As the construction of more and more systems were completed and turned over to the startup group, they would perform integrating testing and make necessary adjustments until they had possession of all of the plant systems.
18. After the completion of all power plant system construction, the startup group would commence full power plant startup testing and commissioning. Commissioning in this sense referred to achieving a successful operational status of each system such that it could be turned over to the owner.
19. The startup group was in control of the turnover of systems to the owner until all systems were in the possession of the owner.
20. At this point the startup group would startup the plant until full power production was achieved.
21. During this startup phase of the project the startup group was also provided training of all owner personnel that would be involved with the operation and maintenance of the power plant.
22. The startup group would stay onsite for at least the first year of operation serving as a consultant to the owner and training the owner's personnel.

The only function that the startup group was immune to was cost. They were never involved with the cost control functions of the project, leaving them totally free from economic influences and pressures when it came to the operation of the power plant.

This whole system of power plant startup seemed to successfully bridge the gap between the design and construction of the plant and the operation of the plant. The ultimate goal of the startup group was to provide a high level of satisfaction to the owner with what they had purchased.

Building Commissioning

Building Commissioning is like commissioning a ship.

- The captain takes the building for a trial run prior to setting sail with occupants.
- The performance of the building is compared to the design intent and areas requiring adjustment or correction are identified.

Identification is the key action that the commissioning process brings forward. Commissioning is not intended to be a “fix it” or “catch all” activity. It is designed to offer a continual review process with the singular goal of giving the owner of the project what they want in the end.

The State of Florida though it's Florida Design Initiative has concluded that:

- The majority of buildings delivered by the common design, bid, build procedure have substantive defects-which are often not found during normal operation.
- Commissioning is a means of discovering, and/or avoiding, such defects so that the building will function as intended and as the owner expects and believes.

From Commissioning to Total Building Commissioning (TBC)

Historically, the term “commissioning” has referred to the process by which the heating, ventilation and air conditioning (HVAC) systems of a building were tested and balanced according to established standards prior to acceptance by the building owner. Today's use of commissioning recognizes the integrated nature of all building systems' performance, which impact sustainability, workplace productivity, occupant safety and security.

Total building commissioning would involve the commissioning of all building systems as defined below:

- Systematic process of assuring by verification and documentation, from the design phase to a minimum of one year after construction, that all facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs, including preparation of operation personnel.

The intended benefits of TBC

Because all building systems are integrated, a deficiency in one or more components can result in suboptimal operation and performance among other components. Remedying these deficiencies can result in a variety of benefits including:

- Improved building occupant productivity
- Lower utility bills through energy savings
- Increased occupant and owner satisfaction
- Enhanced environmental/health conditions and occupant comfort
- Improved system and equipment function
- Improved building operation and maintenance
- Increased occupant safety
- Better building documentation
- Shortened occupancy transition period
- Significant extension of equipment/systems life cycle

The Economics of TBC

- The average operating costs of a commissioned building range from 8% to 20 % below that of a non-commissioned building.
- Building commissioning for office buildings can result in energy savings of 20 to 50% and Maintenance savings of 15 to 35%.
- The one-time investment in commissioning for a building, ranging from 0.5% to 1.5% of construction cost, can result in reduced operating costs over the life of the building.

Commissioning Process

The fundamental objectives of the commissioning process are:

- To create a procedure to verify and provide documentation that the performance of the facility and its systems meet the owner's requirements.
- To enhance communication by documenting data and decisions throughout all phases of the project.
- To validate and report that building system performance meets the design intent.

The commissioning process falls into five phases:

- The program phase
- The design phase
- The construction phase
- The acceptance phase
- The post-acceptance phase

The facility program phase

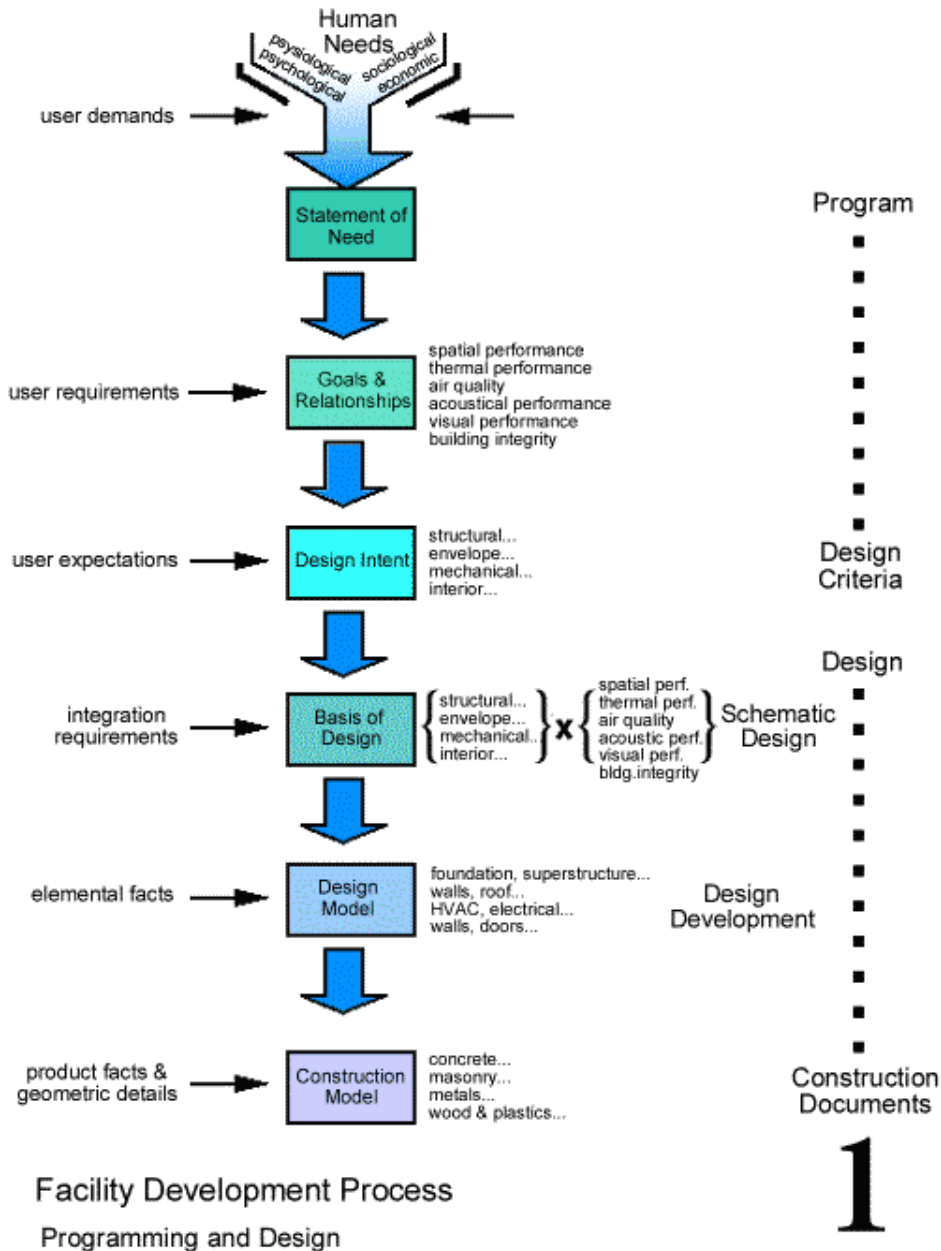
- The functional, operational and occupant requirements of the facility are defined.
- Construction schedules and budgets are planned and a project management plan is developed.
- An initial statement of design intent and a preliminary commissioning plan are prepared.

Identify and layout the makeup of the Commissioning Team

The exact size and members of the commissioning team will vary depending on project type, size and complexity, however in general the team will consist of:

1. Project Manager (Team Leader)
2. Operation Personnel
3. Customer Agency Representatives
4. Technical Experts (i.e. Structural, Mechanical, Electrical, Fire Protection, Elevator, Seismic, LEED/Sustainability, etc.)
5. Construction Manager
6. Construction Contractors & Subcontractors
7. Commissioning Agent
8. Architect/Engineer

The design phase



- The complete design of the facility including all systems is completed including the development of construction drawings and project specifications.
- The commissioning plan and commissioning specification are prepared.
- Design Stage commissioning activities serve to assure that the Owner's Project Requirements for items such as energy efficiency, sustainability, indoor environmental quality, fire protection & life safety, etc. are sufficiently defined and adequately & accurately reflected in the contract documents. The Design Stage is the Commissioning Team's opportunity to assure that building systems and assemblies as designed will function according to user expectations.
- Commissioning services for Design and Construction Management professionals shall minimally include, but are not limited to the items listed in the following:

Design Professional

1. Participate & aid in the documentation of the Owner's Project Requirements.
2. Document revisions to Owner's Project Requirements and obtain GSA Approval.
3. Document the Basis of Design.
4. Integrate Commissioning process requirements & activities provided by the Commissioning Agent into the contract documents.
5. Attend Commissioning Team meetings (3 Design Review Meetings and monthly Construction Stage Commissioning Team meetings).
6. Specify & verify that the operation & maintenance of the systems & assemblies have been adequately detailed in the construction documents.
7. Review & incorporate as appropriate the Commissioning Agent's comments into the contract documents.
8. Participate in the operations and maintenance personnel training as specified in the training program.
9. Review test procedures submitted by the contractor.
10. Review & comment on the Commissioning Agent's progress reports and issue logs.
11. Witness the functional testing of all commissioned systems and assemblies.

12. Review and accept record documents as required by the contract documents.
13. Review and comment on the final Commissioning Record.
14. Recommend final acceptance of the systems to GSA.
15. Verify systems are installed as specified.

Construction Manager

1. If appropriate, lead the RFQ process for commissioning services and award a contract to a Commissioning Agent directly under the Construction Manager.
2. Include commissioning process activities and requirements into all General Contractor Bid Packages.
3. Work with the Commissioning Team to develop a schedule for commissioning activities and incorporate commissioning activities into the overall project schedule
4. Provide personnel with the means and authority to coordinate implementation of the commissioning process as detailed in the contract documents.
5. Attend Commissioning Team meetings (3 Design Review Meetings and monthly Construction Stage Commissioning Team meetings).
6. Coordinate with the Commissioning Agent in development of a Commissioning Plan.
7. Perform quality control functions, particularly in the areas of design reviews for constructability and inspection.
8. Participate in and assist with the functional testing of all commissioned systems and assemblies.
9. Provide technical expertise such as testing, cost estimating and resolving disputes.
10. Coordinate & document Owner/Operator training.
11. Issue a statement that certifies all work has been completed and the facility is operational, in accordance with the contract documents.
12. Coordinate General Contractor remedies for deficiencies identified by the Commissioning Agent during their verification of the installation or tests.
13. Review and comment on the final Commissioning Record.

The construction phase

- The facility is constructed, utility services established and systems and equipment installed.
- The commissioning plan is modified to reflect changes made to systems and equipment.

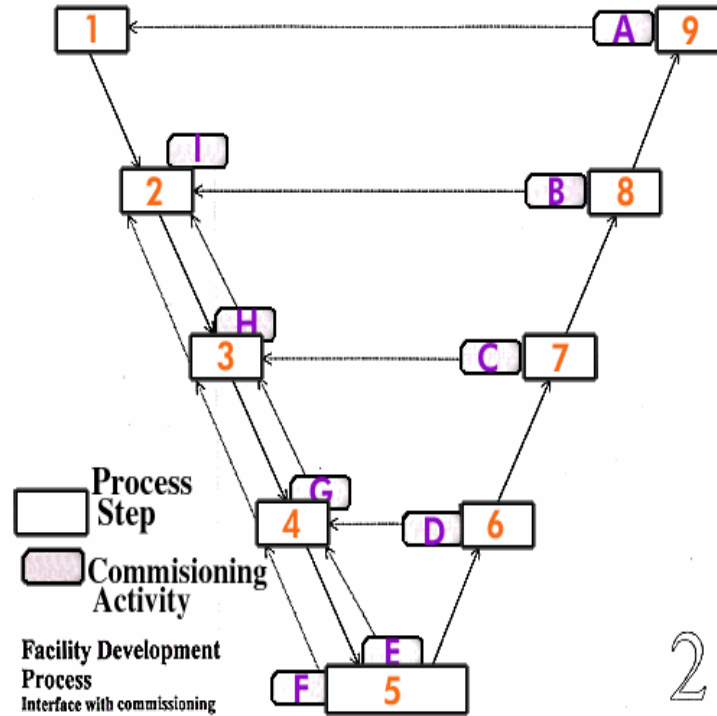
The acceptance phase

- Performance testing is conducted to verify that performance of the systems meet the objectives defined in the design intent.
- Building system O&M documentation is reviewed and approved.
- The maintenance staff is trained on O&M procedures.

The post-acceptance phase

- The building is occupied.
- Performance testing is continued to account for dynamic changes that occur in a facility over time including seasonal variations.

The following charts shows how various commissioning activities correspond with the project development phases;



Key:

Process Step---Commissioning Activity

1. User Needs
2. Program---*I. Commission Plan*
3. Design---*H. Design Validation*
4. Construction Documents--- *G. Construction Document Validation*
5. Construction--- *E. Source QC Validation & F. Change Validation*
6. Acceptance--- *D. Field QC Validation*
7. Startup--- *C. Functional Validation*
8. Shakedown--- *B. Performance Validation*
9. Occupy--- *A. User Validation*

Commissioning Plan

The commissioning plan is the document that describes all aspects from beginning to end of the commissioning process for a facility.

- The plan is continually updated to reflect changes in the program, design and construction of the facility.

- The plan must be organized in a consistent manner that reflects the nature of the building requirements and evaluation procedures for validating the building's performance.

Contents of the Commissioning Plan

1. Facility Program
2. Design Intent
3. Basis of Design
4. Commissioning Specifications
5. Schedules
6. Responsibilities
7. Documentation Requirements
8. Communication and reporting protocols
9. Evaluation procedures for design, contract document and test procedure review and validation

Facility Program

- Identifies the owner's needs in terms of physiological, sociological and economic demands of the owner and the users occupying the facility.
- Establishes the criteria for accomplishing the owner's needs.
- During facility programming the scope of building commissioning is set and commissioning responsibilities and documentation are determined.
- Additionally, the design intent program information and data sources are documented.

Design Intent

- Describes the functional and operational requirements to meet the program needs of the owner.
- Specific performance expectations are identified

The design intent should include the following:

- Objectives and functional requirements of the facility and building systems
- General system descriptions

- General quality of materials and construction
- Occupancy requirements
- Performance criteria
- Acceptance criteria
- Environmental quality
- Schedule and budget considerations
- Restrictions and limitations
- Cost effective equipment and system maintainability

Performance requirements included in the design intent are analogous to the attributes in a performance specification and could include the following.

Structural safety and serviceability	Health and hygiene
Fire and accident safety	Indoor environment
Durability over the service life	Light
Communication ability and capacity	Acoustics
Accessibility (ADA)	Security
Functionality according to use	Aesthetics
Constructability	Adaptability
Maintainability	

Basis of Design

- The basis of design is the documentation of the primary decision making process and assumptions behind the design decisions that were made to meet the design intent.
- Includes a description of the systems, components, conditions and methods chosen to meet the design intent.
- A process of design validation is used to evaluate the basis of design to determine compliance with the design intent.

The basis of design should include the following:

- System and component descriptions

- System performance assumptions
- System and equipment maintainability
- Codes and standards applied
- Energy performance
- Sequence of operations
- Operating control parameters
- Schedules
- Load and design assumptions and calculations
- Equipment and system maintenance life cycle cost analysis

Commissioning Specifications

The commissioning specification is the contract document that describes in detail the construction and acceptance phases of the commissioning process.

Although commissioning is a separate activity from construction, successful commissioning requires certain quality assurance and quality control measures, as defined in the commissioning plan, to be performed along with construction.

Commissioning may be performed as part of the construction contract or separately by a third party.

The general construction QA/QC/Commissioning processes fall into 3 categories:

- Traditional QA/QC procedures to prove compliance with the contract documents. These may include shop drawing, inspections, tests, punch lists and startup procedures. These are specified in the body of the traditional specification. i.e., concrete testing or electrical component testing.
- Those procedures that ascertain a necessary level of system performance. These are commissioning activities such as testing adjusting and balancing to a basis of design and performance verification to a design intent.
- Requirements for operation and maintenance manuals and training which are part of the commissioning plan.

The *Master Format* 2004 edition allows for traditional QA/QC activities scattered throughout its product oriented classifications.

- i.e., Section 04 08 00 Commissioning of Masonry
- i.e., Section 12 08 00 Commissioning of Furnishings
- i.e., Section 22 08 00 Commissioning of Plumbing
- i.e., Section 31 08 00 Commissioning of Earthwork

The *Master Format* 2004 edition listing of commissioning areas is appears to be somewhat limited. That is due to the fact that some of the system related commissioning activities are specified in their corresponding product listing. It may be more prudent to bring those forward under section 01 91 such that the true commissioning activities for integrated system verification are all listed together.

The *Master Format* 2004 edition also provides a commissioning section as follows:

01 90 00 LIFE CYCLE ACTIVITIES

01 91 00 Commissioning

- 01 91 13 General Commissioning Requirements
- 01 91 16 Facility Substructure Commissioning
 - 01 91 16.13 Foundation Commissioning
 - 01 91 16.53 Basement Construction Commissioning
- 01 91 19 Facility Shell Commissioning
 - 01 91 19.13 Superstructure Commissioning
 - 01 91 19.43 Exterior Enclosure Commissioning
 - 01 91 19.73 Roofing Commissioning
- 01 91 23 Interiors Commissioning
 - 01 91 23.13 Interior Construction Commissioning
 - 01 91 23.43 Stairways Commissioning
 - 01 91 23.73 Interior Finishes Commissioning

01 92 00 Facility Operation

- 01 92 13 Facility Operation Procedures

01 93 00 Facility Maintenance

- 01 93 13 Facility Maintenance Procedures
- 01 93 16 Recycling Programs

01 94 00 Facility Decommissioning

- 01 94 13 Facility Decommissioning Procedures

As a minimum, a commissioning specification should address the following areas:

Foundation Systems	Plumbing systems
Structural Systems	Lighting Systems
Exterior Envelope Systems	Electrical Systems
Mechanical and Energy Systems	Roofing Systems
Fire Protection Systems	Interior Systems
Telecommunications systems	Elevator Systems

Evaluation Procedures

The commissioning specifications will provide a clear description of the extent of verification testing required including:

- responsibilities of various parties
- what to test
- test conditions
- reporting protocols
- acceptance criteria
- acceptable test methods
- scheduling requirements
- documentation requirements

The commissioning specifications should outline system performance testing and verification procedures including:

- Testing, adjusting and balancing
- Equipment performance
- Subsystem performance consisting of equipment combinations
- Automatic control performance in all seasonal modes
- Integrated system performance
- Life safety equipment and system performance as they interface with other system and subsystems

The specifications should also clearly identify the relationship between functional start-up testing and occupancy and longer-range performance testing.

Documentation Requirements

The commissioning plan will require commissioning reports to be prepared to document specific decisions, actions and their resultant effect on complying with the owner's design intent. These reports may include:

- Design Validation Report
- Contract Document Validation Report
- Performance Validation Report
- Final Commissioning Report

Part 2 - Public Sector Commissioning

The federal government's buildings builder is the General Service Administration (GSA). Every building that they build or renovate is performed with the following mandate:

Prospectus level projects (new and modernization) planned for 2006 and thereafter shall adopt a Total Building Commissioning practice beginning with the project planning stage and concluding with the post occupancy evaluation phase. These projects shall include provisions for Total Building Commissioning cost in their budget,

For projects that have already received funding approval prior to 2005, a limited commissioning practice shall be adopted to meet project performance objectives.

- *Repair & Alterations projects, where the scope of work is limited to HVAC upgrades, Commissioning for Start-up and Turnover practice shall be adopted.*
- *Repair & Alterations projects, where the scope of work is limited to re-skinning the building, or enclosing an atrium, or providing security and seismic upgrades, commissioning for functional performance testing (FPT) shall be adopted.*
- *All GSA new construction and modernization projects must achieve LEED Certification and must attempt a LEED Silver rating.*

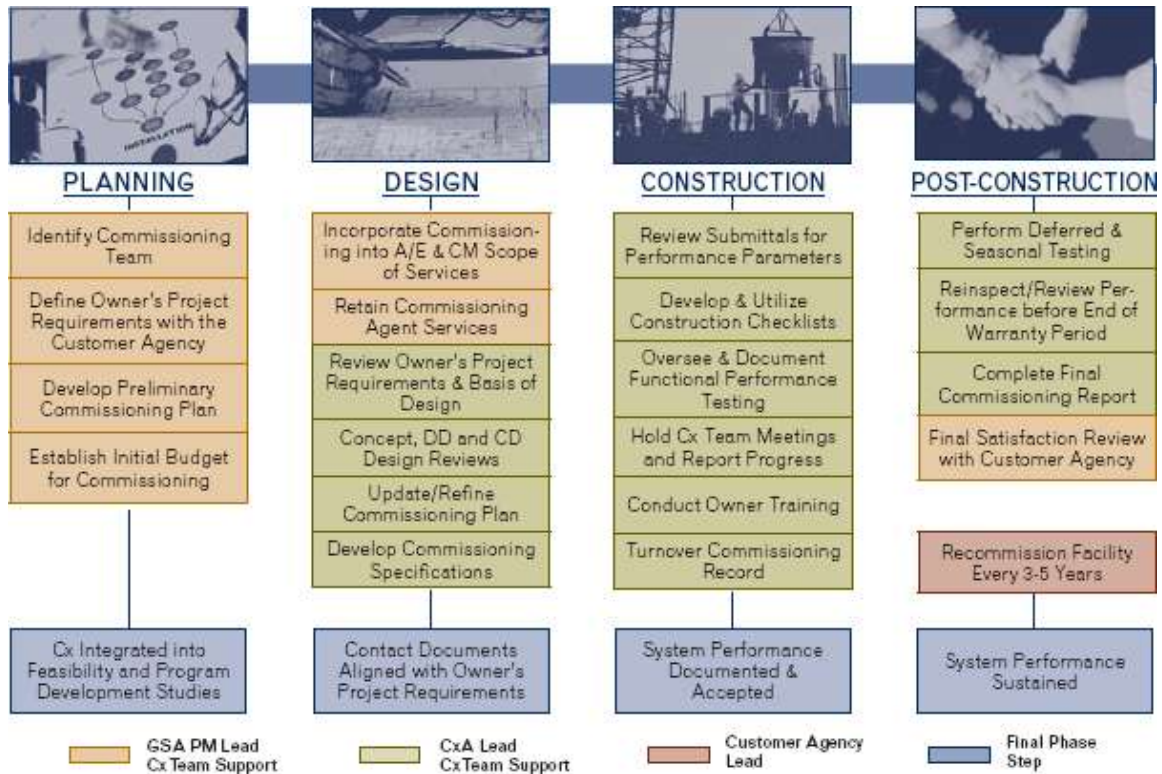
GSA Building Commissioning Guide

The primary audience for this is GSA's Project Managers, their construction management agents, and the Commissioning Agent. The secondary audience for this Guide includes the many stakeholders in the commissioning process including customer agencies, the balance of the project team, other members of government, as well as GSA's partners.

The Building Commissioning Guide provides the overall framework and process for building commissioning from project planning through tenant occupancy, keys to success within each step, and the ways that each team member supports the process of commissioning. While recognizing that every project is unique and that the required activities will vary on every project, this Guide provides recommendations, minimum requirements and best practices based upon industry guidance and GSA experience. The Building Commissioning Guide

encourages the use of these best practices to ensure completeness and consistency nationwide and to address the facility needs of the Customer Agency.

Building Commissioning Process



Planning Stage

For the purpose of this document, the Planning Phase encompasses GSA's Pre-Planning, Feasibility Study and Program Development Study (PDS) activities per

The Project Planning Guide,

Consideration for commissioning is critical even at the Planning Stage of a project. During this stage, the GSA Project Manager (PM) must establish commissioning as an indelible piece of the overall delivery process. Adequate consideration for commissioning scope, budget and schedule shall be included in the Feasibility Study and Program Development Study (PDS). Further, it is at this stage that the Owner's Project Requirements are developed in concert with the

Customer Agency. These requirements establish the benchmarks for performance later in the commissioning process.

Identify Commissioning Team

The first step in the commissioning process is for the GSA PM to identify and layout the makeup of the Commissioning Team. The exact size and members of the commissioning team will vary depending on project type, size and complexity, however in general the team will consist of:

- GSA Project Manager (Team Leader)
- GSA Operating Personnel
- Customer Agency Representative(s)
- GSA Technical Experts (i.e. Structural, Mechanical, Electrical, Fire Protection, Elevator, Seismic, LEED/Sustainability, etc.)
- Construction Manager (CM)*
- Construction Contractor and Subcontractors
- Commissioning Agent (CxA)
- Architect/Engineer (A/E)

Responsibilities of Commissioning Team

The Commissioning Team is responsible for working as a cohesive unit to assure that all of the steps in the commissioning process are completed and the facility objectives are met. The Commissioning Roles & Responsibilities Matrix on the following pages is a summary interpretation of individual roles of team members. The Project Planning Tools' Commissioning Tool offers an expanded Roles & Responsibilities Matrix to address project delivery/commissioning tasks, all of which can be edited to suit unique project requirements. Even though it is likely that key team members (i.e. CM, A/E, CxA) will not be on board at this stage of the project, completion of a project specific roles & responsibilities matrix will help the GSA PM develop the A/E, CM and CxA contract scope for commissioning. This initial roles & responsibilities matrix will be updated and confirmed during the design and construction stages once these team members are contracted.

The following definitions apply to the Roles & Responsibilities Matrix:

- Lead (L) = Direct and take overall responsibility for accomplishment
- Support (S) = Provide assistance

- Approve (A) = formally accept—either written or verbal depending on the situation
- Participate (P) = Take part in the activity (i.e. attend the meeting, etc.)
- Inform (I) = Make this party aware of the activity or result or provide a copy of the deliverable
- Verify (V) = Confirm the accuracy or completeness of the task

Commissioning Roles & Responsibilities Matrix								
Legend	GSA Project Manager	GSA Operating Personnel	Customer Agency Reps	GSA Technical Experts	Construction Manager	Construction Contractor	Commissioning Agent	Architect/ Engineer
Planning Stage								
Identify Commissioning Team	L/A	S	S	P/S				
Develop Owner's Project Requirements	L/A	S	S	S				
Develop preliminary commissioning scope	L	S	S	P/S				
Develop Preliminary Commissioning Plan	L	S	S	S				
Establish budget for all Cx work & integrate costs for commissioning into project budget	L	S	S	S				
Include time for Cx in initial project schedule	L	I	I	I				
Include Cx responsibilities in A/E & CM scope of services	L/A	S		S				
Design Stage								
Contract for Commissioning Agent Services	L/A	P	P	P	L			
Hold Design Stage Cx meetings	P	P	P	P	P		L	P
Identify project specific responsibilities	L	P	P	S	S		P	P
Review Owner's Project Requirements documentation for completeness & clarity	S	S	I		I		L	I
Develop Basis of Design	A	P	P	S/A	I		I	L
Perform focused Cx reviews of design drawings & specifications	P	P		P	S		L	S
Perform project constructability reviews	P			I/P	L		I/S	S
Incorporate appropriate changes to contract documents based upon design reviews	A	P	P	I	I		I	L
Refine Owner's Project Requirements based upon Design Stage Decisions	A	P	P	S	I		L	S
Create Cx specifications including testing protocols for all commissioned equip./systems	I	I	I	P/S	S		L	S
Integrate Cx activities into project schedule	A	I	I	I	L		S	I
Coordinate integration issues & responsibilities between equipment, systems & disciplines	A	I	I	P/S	S		V	L

Commissioning Roles & Responsibilities Matrix								
Legend	GSA Project Manager	GSA Operating Personnel	Customer Agency Reps	GSA Technical Experts	Construction Manager	Construction Contractor	Commissioning Agent	Architect/Engineer
Update Commissioning Plan	A	I	I	I	S		L	I
Incorporate commissioning requirements into Construction Contractor's Scope of Work	A			I	L		S	S
Construction Stage								
Revise Commissioning Plan as necessary	A	I	I	I	I	S	I	L
Review submittals applicable to equipment/systems being commissioned	I			P	A	S	S	L
Review project submittals for construction quality control & specification conformance	I			I/P	A	L	S	V
Develop functional test procedures and documentation formats for all commissioned equipment & assemblies	A	I	I	S/A	S	S	I	L
Include Cx requirements and activities in each purchase order and subcontract written	A					A	L	V
Develop construction checklists for equipment/systems to be commissioned	A			P	I	I	I	L
Install components & systems	I	I	I		A	A	L	V
Review RFIs and changes for impacts on Cx	A	I	I	I/S	S	L	S	V
Demonstrate operation of systems	I		P/I		I	P	L	V
Complete construction checklists as the work is accomplished	I	I		I	I	S	L	A
Continuously maintain the record drawings and submit as detailed in the contract documents	A	S			I	S	L	V
Coordinate functional testing for all commissioned systems & assemblies	I	I	I	P/A	I	S	S	L/A
Perform quality control inspections	I			I/P		L	S	P/I
Maintain record of functional testing	I	I	I	I/P	I	S	S	L

Commissioning Roles & Responsibilities Matrix								
Legend L = Lead P = Participate S = Support I = Inform A = Approve V = Verify	GSA Project Manager	GSA Operating Personnel	Customer Agency Reps	GSA Technical Experts	Construction Manager	Construction Contractor	Commissioning Agent	Architect/ Engineer
	Prepare Cx Progress Reports	A	I	I	I/P	I	P	S
Hold Construction Phase Cx meetings	P	P	P	P	P	P	P	L
Maintain master Issues Log	I	I	I	I	I	S	I	L
Review equipment warranties to ensure GSA responsibilities are clearly defined	I	I				S	S	L
Implement training program for GSA Operating Personnel	I	P	P	I/S	P	S	S	L
Compile and deliver Turnover Package	A	A			S	S	L	S/V
Deliver Commissioning Record (see page 48)	A	P	P	I	S	S	S	L
Post-Construction Stage								
Coordinate & supervise deficiency corrections	A	P		I	I/S	L	S	I
Coordinate & supervise deferred & seasonal testing	A	P		I		S		I
Review & address outstanding issues	A	P		I	I/S	S	S	I
Review current building operation at 10 months into 12 month warranty period	A	P		I	S	S		I
Address concerns with operating facility as intended	A	P		I	S	S	S	S
Complete Final Commissioning Report	A	P			I/P	I		I
Perform Final Satisfaction Review with Customer Agency 12 months after occupancy	A	S		S		S		S
Recommission the facility at 3-5 years after turnover to reset optimal performance	L	P		L	P			

* Commissioning Agent Services will likely be required for the periodic recommissioning of the facility. While contracting with the original project CxA may offer some efficiencies, GSA may or may not elect to contract with the project CxA.

Define Owner's Project Requirements with the Customer Agency

The objective of commissioning is to provide documented confirmation that a facility fulfills the functional and performance requirements of GSA, occupants and operators. To attain this goal, it is necessary to establish and document Owner project requirements and criteria for system function, performance and maintainability. The Owner's Project Requirements will form the basis from which all design, construction, acceptance and operational decisions are made. The following suggested categories provide a framework for the types of requirements that shall be considered.

Accessibility	Access and use by children, aged and disabled persons
Acoustics	Control of internal and external noise and intelligibility of sound
Comfort	Identify and document those comfort problems that have caused complaints in the past and which will be avoided in this facility (i.e. glare, uneven air distribution, etc.)
Communications	Capacity to provide inter- and intra-telecommunications throughout the facility
Constructability	Transportation to site, erection of facility and health & safety during construction
Design Excellence	Potential/Objectives for design recognition
Durability	Retention of performance over required service life
Energy	Goals for energy efficiency (to the extent they are not called out in the Green Building Concepts)
Fire Protection & Life Safety	Fire protection and life safety systems
Flexibility	For future facility changes and expansions
Green Building Concepts	Sustainability concepts including LEED certification goals
Health & Hygiene	Protection from contamination from waste water, garbage and other wastes, emissions & toxic materials
Indoor Environment	Including hygrothermal, air temperature, humidity, condensation, indoor air quality and weather resistance
Life Safety	Fire protection and life safety systems
Light	Including natural and artificial (i.e. electric, solar, etc.) illumination
Maintenance Requirements	Varied level of knowledge of maintenance staff and the expected complexity of the proposed systems
Security	Protection against intrusion (physical, thermal, sound, etc.) and vandalism and chemical/biological/radiological threats
Standards Integration	Integration of approved Federal, State & local as well as GSA and Customer Agency standards & requirements
Structural Safety	Resistance to static & dynamic forces, impact and progressive collapse

Obtaining the information and criteria for the Owner's Project Requirements necessitates input from all key facility users and operators. The Owner's Project Requirements shall be developed in keeping with the processes detailed in GSA's *Project Planning Guide* including use of *P-100* standards, facility specific (i.e. courthouse, border station, etc.) design guidelines and project programming methodologies. In some cases the owner is likely to have a canned set of project requirements. Note that the Project Planning Tools' input data includes typical GSA program goals, which when activated, triggers default/suggested commissioning language the PPT's Commissioning Plan outputs.

The Owner's Project Requirements will evolve throughout each project stage. As decisions are made throughout the Planning, Design and Construction Stages, the Project Requirements will be updated. It is the primary tool for benchmarking success and will ultimately become part of the Systems Manuals documentation.

Develop Preliminary Commissioning Plan

The Commissioning Plan establishes the framework for how commissioning will be handled and managed on a given project. This includes a discussion of the commissioning process, schedule, team and team member responsibilities, communication structures and a general description of the systems to be commissioned. This preliminary version of the Plan shall be developed by the GSA PM in conjunction with the Customer Agency. The suggested structure of the Commissioning Plan is as follows. All information in the Commissioning Plan must be project specific.

Introduction	Purpose and general summary of the Plan.
General Project Information	Overview of the project, emphasizing key project information and delivery method characteristics.
Commissioning Scope	The commissioning scope including which building assemblies, systems, subsystems and equipment will be commissioned on this project.
Team Contacts	Project specific Commissioning Team members and contact information.
Communication Plan & Protocols	Documentation of the communication channels to be used throughout the project.
Commissioning Process	Detailed description of the project specific tasks to be accomplished during the Planning, Design, Construction and Tenant Occupancy Stages with associated roles & responsibilities.
Commissioning Documentation	List of commissioning documents required to identify expectations, track conditions and decisions and validate/certify performance.
Commissioning Schedule	Specific sequences of events and relative timeframes, dates and durations.

The Commissioning Agent will add to this preliminary Plan in the Design and Construction Phases by assembling and completing the Commissioning Plan Appendices as detailed below. The completed Appendices will form the Commissioning Record turned over at the end of the construction stage (see “Turnover Commissioning Record”).

Appendices	Work completed during the commissioning process
A	Owner's Project Requirements
B	Basis of Design
C	Commissioning Specifications
D	Design Review
E	Submittal Review
F	Issues Log
G	Construction Checklists
H	Site Visit and Commissioning Meeting Minutes
I	O&M Manual Review
J	Training
K	Functional Performance Tests & Seasonal Testing
L	Warranty Review
M	Test Data Reports

The initial commissioning scope is derived from Customer Agency, GSA PM & Operating Personnel input as well as previous experience with similar buildings. The Commissioning Systems Selection Matrix provided in Appendix B of this Guide is a useful tool in selecting systems to commission for a particular facility type. Exact systems shall be determined on a project to project basis.

Commissioning for Certifications (LEED, Energy Star, etc.)

Development of the preliminary Commissioning Plan and initial commissioning scope shall also include a discussion regarding project certifications and goal attainment (i.e. LEED, Energy Star, Energy Goals, Design Awards, etc.). For the project to be LEED certified commissioning process activities must comply with the prerequisite requirements for fundamental building commissioning and the project team may opt to pursue an added LEED point for additional commissioning. The process provided in this Guide provides the necessary steps to comply with both prerequisite and additional commissioning

requirements. The LEED 2.1 commissioning criteria is explained in more detail below.

LEED Commissioning Criteria Energy & Atmosphere Prerequisite 1

Fundamental Building Systems Commissioning

INTENT

Verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended.

REQUIREMENTS & SUBMITTALS

1. Engage a commissioning authority
2. Review design intent & Basis of Design (BOD) documentation
3. Include Cx requirements in construction documents
4. Develop & utilize a Commissioning Plan
5. Verify installation, functional performance, training and documentation
6. Complete a commissioning report

Energy & Atmosphere Credit 3 (1 Pt.) Additional Commissioning

INTENT

Verify and ensure that entire building is designed, constructed and calibrated to operate as intended.

REQUIREMENTS & SUBMITTALS

(7-9 must be done by independent 3rd Party)

1. Engage a commissioning authority
2. Review design intent & BOD documentation
3. Include Cx requirements in construction documents
4. Develop & utilize a Commissioning Plan
5. Verify installation, functional performance, training and documentation
6. Complete a commissioning report
7. Conduct a focused review of the design prior to CD phase
8. Conduct a focused review of the Construction Documents when close to completion
9. Conduct a selective review of contractor submittals of commissioned equipment
10. Develop a recommissioning management manual
11. Have a contract in place to review with operational staff current building operation, including plan for resolution of outstanding commissioning related issues within 1 year after completion of construction.

Establish Initial Budget for Commissioning

Based upon the Preliminary Commissioning Plan, the GSA Project Manager includes budgetary costs for commissioning in the Feasibility Study and the Program Development Study. It is critical that the overall established budget which is submitted for funding approval contains necessary monies for commissioning.

Specifically, Feasibility Study and Program Development Study deliverables per GSA's *Project Planning Guide* call for estimated construction costs (ECC) and estimated total project costs (ETPC). These estimates must include line items for both commissioning services and testing.

Commissioning Agent Costs

Total building commissioning costs for Commissioning Agent services can range from 0.5% to 1.5% of total construction costs (according to U.S. Department of Energy's Rebuild America Program, written by the Portland Energy Conservation, Inc. (PECI)). The National Association of State Facilities Administrators (NASFA) recommends budgeting 1.25 to 2.25% of the total construction costs for total building Commissioning Agent services.

GSA's commissioning practice is expected to cost approximately 0.5% of the construction budget for federal buildings and border stations. More complex projects such as courthouses could run 0.8 - 1% of the construction budget, and even more complex facilities such as laboratories can exceed 1%. Factors influencing commissioning costs include facility type, phasing 24/7 operations, the depth and breadth of commissioning services, the level of commissioning desired and the systems and assemblies chosen to be commissioned. The chart on the following pages shows benchmark costs per square foot for Commissioning Agent services by facility type.

Additional Project Costs

The above costs only cover Commissioning Agent fees. There are also costs to the Construction Manager, Construction Contractor, A/E and owner staff for their part in the commissioning process. The profile of these costs will vary depending on roles and responsibilities chosen. For a detailed estimate of professional

service fees, an itemized level of effort needs to be performed based on unique project requirements.

Specialty = Very complex facilities—Neutral Buoyancy Laboratory; Mission Control Center; etc.

complex = Moderate plus most of floor area in complex systems (hospitals, labs, operating rooms, clean rooms, fume hoods or other non-HVAC systems are commissioned such as electrical quality, transformers, security, communications, etc. Traveling requirements and high cost of living locations increase costs.

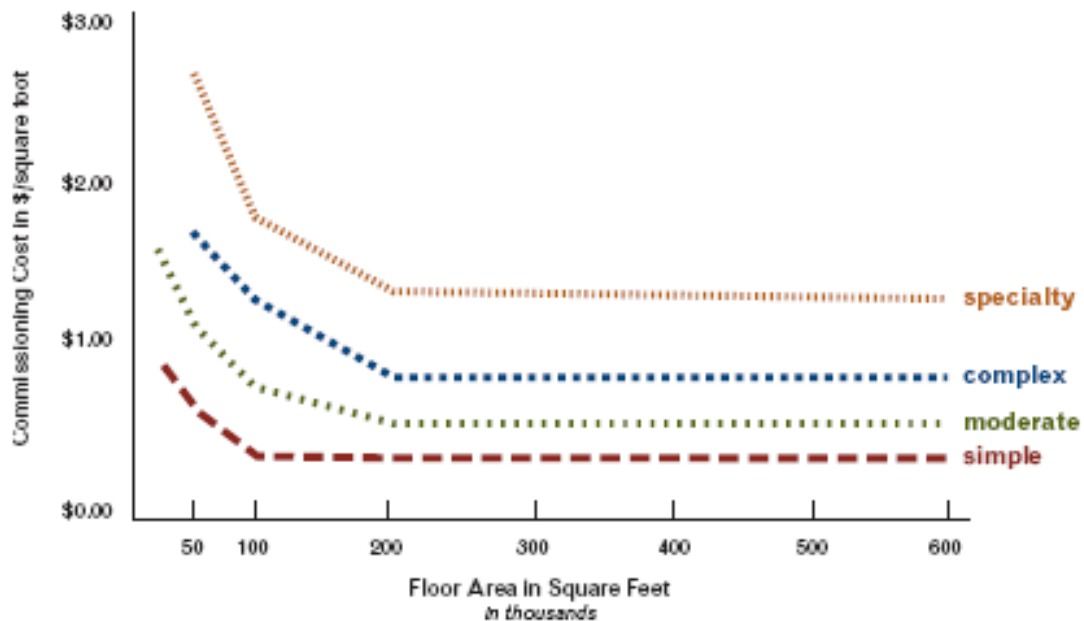
Moderate = More complex office, classroom with some labs, building

Simple = Office buildings, classrooms, packaged equipment and controls; common systems, fewer pieces of equipment.

Benchmark Commissioning Costs by Facility Type

Portland Energy Conservation, Inc. (PECI), 2000

Estimates of Construction Phase Commissioning Costs



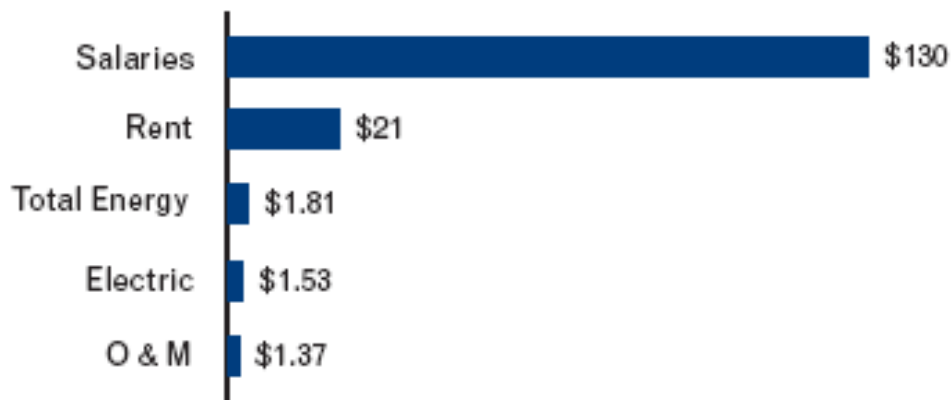
Cost-Benefit Analysis for Commissioning

Recent PECI studies indicate that on average the operating costs of a commissioned building range from 8% to 20% below that of a non-commissioned building. BOMA cost data for office buildings suggests that building commissioning can result in energy savings of 20 to 50% and maintenance

savings of 15 to 35%. Beyond operating efficiency, successful building commissioning has been linked to reduced occupant complaints and increased occupant productivity. The example below demonstrates the financial impact of increased occupant productivity.

The chart below illustrates that salaries dominate average annual commercial expenditures when compared to other operating costs such as facility operations and rent costs. For a standard office building of 250,000 sf, there are approximately 1500 occupants at an average salary of \$40,000 each (taken from US Census Bureau March 2002). This equates to \$78 million/year in salary expenses including fringe benefits. Analyzing potential cost savings, a 10-20% increase in productivity could result in an \$8–16 million dollar impact each and every year.

*Average Annual Commercial Expenditure
in \$ per square foot*



Source: Data from Building Owners and Managers Association; Electric Power Research Institute; Statistical Abstract of the United States, 1991

Building Commissioning Process Design Stage

Design Stage commissioning activities serve to assure that the Owner's Project Requirements for items such as energy efficiency, sustainability, indoor environmental quality, fire protection & life safety, etc. are sufficiently defined and adequately & accurately reflected in the contract documents. The Design Stage is the Commissioning Team's opportunity to assure that building systems and assemblies as designed will function according to user expectations. Further,

specific tests and procedures designed to verify the performance of systems and assemblies are developed and incorporated into the contract documents.

Incorporate Commissioning into A/E & CM Scope of Services

GSA commissioning activities may be more rigorous than A/Es and CMs typically include in their scope of services. Design, Construction & Post-Construction commissioning activities must be defined and written into the Architect/Engineer and Construction Manager scopes of work and executed contracts.

By this stage of project development, the GSA Project Manager must have an awareness of how commissioning services will be delivered. GSA's preferred method for engaging a Commissioning Agent is to arrange for the Construction Manager to contract directly with a Commissioning Agent, however there will be exceptions based on project specific drivers. Should the project team determine that the CM will contract the commissioning agent, this must be written into the CM's scope of work. Commissioning services for Design and Construction Management professionals shall minimally include, but are not limited to the items listed on the following page.

A/E & CM Commissioning Scope Items

Design Professional

1. Participate & aid in the documentation of the Owner's Project Requirements.
2. Document revisions to Owner's Project Requirements and obtain GSA Approval.
3. Document the Basis of Design.
4. Integrate Cx process requirements & activities provided by the CxA into the contract documents.
5. Attend Commissioning Team meetings (3 Design Review Meetings and monthly Construction Stage Cx Team meetings).
6. Specify & verify that the operation & maintenance of the systems & assemblies have been adequately detailed in the construction documents.
7. Review & incorporate as appropriate the CxA's comments into the contract documents.
8. Participate in the operations and maintenance personnel training as specified in the training program.
9. Review test procedures submitted by the contractor.
10. Review & comment on the CxA's progress reports and issue logs.
11. Witness the functional testing of all commissioned systems and assemblies.
12. Review and accept record documents as required by the contract documents.
13. Review and comment on the final Commissioning Record.
14. Recommend final acceptance of the systems to GSA.
15. Verify systems are installed as specified.

Construction Manager

1. If appropriate, lead the RFQ process for commissioning services and award a contract to a Commissioning Agent directly under the Construction Manager.
2. Include commissioning process activities and requirements into all General Contractor Bid Packages.
3. Work with the Commissioning Team to develop a schedule for commissioning activities and incorporate commissioning activities into the overall project schedule.
4. Provide personnel with the means and authority to coordinate implementation of the commissioning process as detailed in the contract documents.
5. Attend Commissioning Team meetings (3 Design Review Meetings and monthly Construction Stage Cx Team meetings).
6. Coordinate with the Commissioning Agent in development of a Commissioning Plan.
7. Perform quality control functions, particularly in the areas of design reviews for constructability and inspection.
8. Participate in and assist with the functional testing of all commissioned systems and assemblies.
9. Provide technical expertise such as testing, cost estimating and resolving disputes.
10. Coordinate & document Owner/Operator training.
11. Issue a statement that certifies all work has been completed and the facility is operational, in accordance with the contract documents.
12. Coordinate General Contractor remedies for deficiencies identified by the Commissioning Agent during their verification of the installation or tests.
13. Review and comment on the final Commissioning Record.

Retain Commissioning Agent Services

GSA's suggested practice is to have the Construction Manager hire a subcontractor to act as the Commissioning Agent, resulting in no additional contract management responsibilities for GSA. In this case the CM will lead the RFQ process for commissioning services. There will be exceptions to this suggested practice, and in these cases, GSA will lead the RFQ process for a Commissioning Agent. Regardless of the contracting method, the Commissioning Agent shall be on board by the beginning of Design Development.

Commissioning Agent Qualifications

The Commissioning Agent and the Construction Manager generally have different skills. In general, the Construction Manager provides management, technical and administrative expertise during the design and construction phases to ensure that the Customer Agency's goals relating to schedule, budget, scope and quality are met. A Commissioning Agent has technical background and in depth expertise with the commissioning process including verification techniques, functional performance testing, system equipment and O&M knowledge.

A list of recommended criteria, which shall be incorporated into an RFQ for commissioning services, is included in Appendix B. The Commissioning Agent must have significant in-building commissioning experience, including technical and management expertise on projects of similar scope, size and type. Further the CxA shall bring a total building commissioning perspective to the project, be knowledgeable in national building fire codes, as well as water-based extinguishing systems, detection systems, LEED, energy efficiency imperatives and demonstrate experience with Federal requirements (i.e. blast, progressive collapse, security, etc.).

Request for Qualifications for Commissioning Agent

The RFQ for Commissioning Agent services is based upon the Preliminary Commissioning Plan and the commissioning budget established in the Program Development Study (PDS). Depending on the CxA delivery method (i.e. CM versus GSA contracts the CxA), this may be the responsibility of either GSA or the CM. If the RFQ is performed by the CM, this format may vary slightly. For

reference, a sample Scope for Commissioning Services is included in Appendix A.

Project Background	Building type, square footage, general program, overall project budget, milestone schedule dates, LEED and other certification pursuits, etc.
Objectives	GSA project objectives for commissioning
Scope of Work	Design, Construction & Post-Construction Stage expectations for the Commissioning Agent
Systems and Assemblies	Preliminary identification of the systems and assemblies to be Commissioned. Once contracted, the CxA will further develop this matrix.
Qualifications	Desired qualification of the CxA
Proposal	Expectations for format & content of prospective CxA's proposal
Change in Personnel	Statement on GSA review of CxA changes in personnel for the project
Selection Criteria	A table indicating the selection criteria and scoring system for evaluating CxA proposals
Proprietary Information (disclaimer)	
Protection and Control of Government Documents (disclaimer)	

Commissioning Agent Selection

This service shall be acquired in the same manner as other professional services. The Commissioning Agent shall be chosen on the primary basis of qualifications and not solely based on price. The involved work order and selection procedures should adhere to the involved IDIQ provisions for work order issuance, and be fitted with requirements/contents that are aligned with standard work order formats. National IDIQ contracts are in place that can support commissioning services.

It is recommended that the CxA is contracted according to a two phase fee negotiation process. The first phase includes Design Stage responsibilities and the second phase includes Construction and Post-Construction activities. This two phase process allows for the negotiation of the initial fee to be based on known general factors, and negotiation of the Construction and Post-

Construction Stage fee based upon a substantially completed design and the actual type and number of equipment, systems and assemblies to be inspected, started and tested. Within the Design Stage proposal, the CxA shall be asked to provide budgetary numbers for the Construction and Post-Construction Stages.

Review Owner's Project Requirements & Basis of Design

As described in previous sections, the Owner's Project Requirements are developed as part of GSA's project planning processes and establish baseline criteria for facility function, performance and maintainability. The Basis of Design (BOD) is developed by the A/E early in the Design Stage based on Owner's Project Requirements. It is the primary document that translates GSA's and the Customer Agency's needs into building components such as HVAC systems, building envelope, security systems, building automation system, etc. The BOD describes the technical approach planned for the project as well as the design parameters to be used. The BOD is typically developed by the A/E and done in technical terms, whereas the Owner's Project Requirements are developed by GSA in concert with the Customer Agency and expressed in layman's terms. When the Commissioning Agent is brought on board early in the design development phase, one of their first tasks is to review the Owner's Project Requirements and the Basis of Design (BOD). The purpose of these reviews is to assure that the Customer Agency's needs are met as described in the Owner's Project Requirements, and carried through in the Basis of Design Document. The CxA's review ensures clarity and completeness with an eye toward commissioning process activities (benchmarks, standards, performance targets, etc.). The CxA may recommend changes to improve energy efficiency, operation & maintenance and equipment reliability. Making changes in the Design Stage, rather than after installation begins, saves money.

Through the design process, a key role for the Commissioning Agent is to facilitate a clear understanding of expectations by the design team. To do this, the practice of conducting program review workshops is to be used to offer all stakeholders the opportunity to indicate what they want to see in the next design submission. The Project Planning Tools' Commissioning Tool identifies such practices in the work breakdown structure associated with defining roles and responsibilities.

Concept, DD and CD Design Reviews

The Commissioning Agent provides three focused reviews of the design documents. It is recommended that these reviews occur first at the end of Design Concepts, the second shall occur during Design Development (50%) and the third toward the end of Construction Documents Phase (95%) (see *P-100* for definition of Concept, DD and CD design phases). The CxA compares the design with the interests and needs of GSA as identified in the Owner's Project Requirements. The CxA also compares the proposed design against GSA design standards as defined in the latest version of the *PBS P-100 Facilities Standards*. The CxA identifies any improvements that can be made in areas such as energy efficiency, indoor environmental quality, operations & maintenance, etc. Though the CxA is responsible for reviewing the design from a commissioning perspective, the CxA is not responsible for design concepts and criteria or compliance with local, State and Federal Codes (unless it is specifically called out in their contract).

Commissioning Agent Focused Design Review Scope

Certification Facilitation	Review contract documents to facilitate project certification goals (i.e. does design meet Energy Star requirements; does Cx meet LEED criteria, etc.)
Commissioning Facilitation	Review contract documents to facilitate effective commissioning (sufficient accessibility, test ports, monitoring points, etc.)
Commissioning Specifications	Verify that bid documents adequately specify building commissioning, including testing requirements by equipment type.
Control System & Control Strategies	Review HVAC, lighting, fire control, emergency power, security control system, strategies and sequences of operation for adequacy and efficiency.
Electrical	Review the electrical concepts/systems for enhancements.
Energy Efficiency	Review for adequacy of the effectiveness of building layout and efficiency of system types and components for building shell, HVAC systems and lighting systems.
Envelope	Review envelope design and assemblies for thermal and water integrity, moisture vapor control and assembly life, including impacts of interior surface finishes and impacts and interactions with HVAC systems (blast, hurricane, water penetration).
Fire Protection & Life Safety*	Review contract documents to facilitate effective Cx of fire protection & life safety systems and to aid Fire Protection Engineer in system testing to obtain the GSA Occupancy Permit
GSA Design Guidelines & Standards	Verify that the design complies with GSA design guidelines and standards (i.e. GSA P-100, Court Design Guide, Border Station Guide and Federal Facility Council requirements).
Functionality	Ensure the design maximizes the functional needs of the occupants.
Indoor Environmental Quality (IEQ)	Review to ensure that systems relating to thermal, visual acoustical, air quality comfort, air distribution maximize comfort and are in accordance with Owner's Project Requirements.
Life Cycle Costs	Review a life cycle assessment of the primary competing mechanical systems relative to energy efficiency, O&M, IEQ, functionality, sustainability.
Mechanical	Review for owner requirements that provide flexible and efficient operation as required in the P-100, including off peak chiller heating/cooling AHU operations, and size and zoning of AHUs and thermostated areas
Operations and Maintenance (O&M)	Review for effects of specified systems and layout toward facilitating O&M (equipment accessibility, system control, etc.).

O&M Documentation	Verify adequate building O&M documentation requirements.
Owner's Project Requirements	Verify that contract documents are in keeping with and will meet the Owner's Project Requirements.
Structural	Review the structural concepts/design for enhancements (i.e. blast & progressive collapse).
Sustainability	Review to ensure that the building materials, landscaping, water & waste management create less of an impact on the environment, contribute to creating a healthful & productive workspace, & are in accordance with Owner's Project Requirements. See also P-100 LEED requirements.
Training	Verify adequate operator training requirements.

Issues Log

All comments and issues identified must be tracked in a formal Issues Log. The Issues Log must be sufficiently detailed so as to provide clarity and a point of future reference for the comments.

The Issues log shall contain at a minimum:

- Description of Issue
- Cause
- Recommendation
- Cost & Schedule Implications (on design, construction & facility operations)
- Priority
- Actions Taken
- Final Resolution

The Issues Log serves as a vehicle to track, critically review and resolve all commissioning related issues. The Issues Log is maintained by the CxA and becomes part of the final Commissioning Record.

Design Review Meetings

The Cx Team shall have a minimum of 3 Design Review Meetings (Kick-off, Concept/DD and CD). Additional meetings may be required to resolve outstanding issues. The CxA is responsible to lead design review meetings and

work collaboratively with the Commissioning Team toward presentation, discussion and resolution of design review comments. Upon resolution of the CxA's comments, the A/E is responsible to incorporate all approved changes into the design documents.

Update/Refine Commissioning Plan

Now that the Commissioning Agent is on board and has performed Design Stage reviews, the team realigns & updates the Commissioning Plan in preparation for the Construction Stage. The Commissioning Team shall formally accept the updated Commissioning Plan before moving into construction. Further, all outstanding comments and issues relative to the CxA's review of the design shall be resolved, and accepted changes shall be incorporated into the contract and construction bid documents.

- Commissioning team directory
- Commissioning process activities
- Roles & responsibilities
- Communication structures
- Commissioned systems & equipment
- Commissioning process schedule
- Appendices (Owner's Project Requirements, BOD, Design Review, Issues Log).

The Commissioning Team shall formally accept the updated Commissioning Plan before moving into construction. Further, all outstanding comments and issues relative to the CxA's review of the design shall be resolved, and accepted changes shall be incorporated into the contract and construction bid documents.

Develop Commissioning Specifications

The commissioning tasks for the contractors will be identified in the commissioning specifications and will include:

General commissioning requirements common to all systems and assemblies

- Detailed description of the responsibilities of all parties
- Details of the commissioning process (i.e. schedule and sequence of activities)
- Reporting & documentation requirements & formats
- Alerts to coordination issues

- Deficiency resolution
- Commissioning meetings
- Submittals
- O&M Manuals
- Construction checklists
- Functional testing process and specific functional test requirements including testing conditions and acceptance criteria
- As-built drawings
- Training

Specifications must clearly indicate who is witnessing and documenting startup of each commissioned system. Specifications must also clearly indicate who is writing, directing, conducting and documenting functional tests. The Commissioning Agent and the A/E must work together to ensure that commissioning requirements are fully integrated and coordinated in the project specifications.

Written Test Procedures

Written functional test procedures define the means and methods to carry out system/intersystem tests during the construction phase. To the extent possible these test procedures shall be defined by the Commissioning Team in the Design Stage and written into contractors' scopes of work. Test procedures will necessarily be refined early in the construction phase based on the submittal process. Tests procedures provide the following:

.Required parties for the test, which may include the CM, Construction Contractor, specific subcontractor(s)), designer, GSA PM, GSA Operating Personnel, GSA Technical Experts and Customer Agency representatives, the roles of each required party must also be clearly defined.

- Prerequisites for performing the test including completion of specific systems and assemblies. Prerequisites are of critical importance when undertaking phased construction and/or phased occupancy. The CxA must coordinate tests with the CM in terms of the overall construction schedule and the anticipated completion of given systems.
- List of instrumentation, tools and supplies required for the test.

- Step-by-step instructions to exercise the specific systems and assemblies during the test. This includes instructions for configuring the system to begin the test, and the procedure to return the system to normal operation at the conclusion of the test.
- Description of the observations and measurements which must be recorded and the range of acceptable results.

Development of project specific test procedures can be expensive. Where possible, baseline GSA test procedures shall be referenced and used as a guide from which to customize project specific procedures.

Building Commissioning Process construction stage

During the Construction Phase the Commissioning Team works to verify that systems and assemblies operate in a manner that will achieve the Owner's Project Requirements. The two overarching goals of the Construction Phase are to assure the level of quality desired and to assure the requirements of the contracts are met. The Construction Phase commissioning activities are a well-orchestrated quality process that includes installation, start-up, functional performance testing and training to ensure documented system performance in accordance with the Owner's Project Requirements. This testing and documentation will also serve as an important benchmark and baseline for future re-commissioning of the facility.

Review Submittals for Performance Parameters

As submittals for products and materials are received from contractors, copies of submittals critical to the commissioning process shall be forwarded to the CxA. In general the CxA reviews the following types of submittals:

- Coordination drawings
- Redline As-builts
- Product data and key operations data submittals
- Systems manuals
- Training program

Clearly, the CxA cannot review every project submittal. The CxA's review of submittals shall be limited to those items that are critical to the focus of the

commissioning process. This review allows the CxA to check the submittals for adherence to Owner's Project Requirements, Basis of Design and Project Specifications. The CxA shall pay special attention to substitutions and proposed deviations from contract documents & the BOD. The CxA will only comment on submittals to the extent that there is a perceived deviation from the Owner's Project Requirements or Commissioning Plan. All CxA comments shall be resolved by the GSA PM, CM, A/E and CxA in a team spirit and documented.

Develop & Utilize Construction Checklists

Construction checklists are developed by Commissioning Agent, maintained by the Construction Manager and used by the Construction Contractor and subcontractors.

The intent of construction checklists is to convey pertinent information to the installers regarding the Customer Agency's concerns on installation and long-term operation of the facility and systems. The approach to the structure of the checklists is to keep it short and simple by focusing on key elements. Checklists span the duration from when equipment is delivered to the job site until the point that the system/component is started up and operational. This includes testing, adjusting and balancing and control system tuning.

Construction checklists are tools for transferring the information contained in the contract documents (drawings and specifications) to the workers in the field. By completing the checklists, the workers are assured that requirements in the project documents are satisfied. Checklists generally fall into the following categories:

- Delivery & storage checks
 - Document & track delivery of equipment & materials to site
 - Verify submittal information (avoid accepting & installing equipment which does not meet specifications)
 - Ensure equipment/materials remain free of contamination, moisture, etc.
- Installation & start-up
 - Component-based checks
 - Systems-based checks

The development of the construction checklists takes close coordination between the GSA PM, GSA Operating Personnel, GSA Technical Experts, CxA, Construction Manager, Construction Contractor, and in some cases, State and local government officials to maximize the benefits and tailor the checklists to the

way the CM and Construction Contractor will manage the project. Generally the checklists are developed as follows:

- CxA identifies components and systems for which checklists are required
- CxA reviews Owner's Project Requirements for key success criteria
- CxA reviews specifications and submittals for key requirements
- CxA develops sample checklists for GSA PM and CM review
- CxA incorporates feedback and finalizes checklists for distribution

Once the checklists have been developed and provided to the Construction Contractor, the CxA will review the completion of the checklists periodically during site visits.

GSA PMs are encouraged to reference the Construction Industry Institute's *Planning for Start-up* Education Module (edited for GSA) for more detail on startup processes and checklists.

Oversee & Document Functional Performance Testing

Functional performance testing takes over where the construction checklists ended. The intent of functionally testing the system/building as a whole is to evaluate the ability of the components in a system to work together to achieve the Owner's Project Requirements. For functional testing to provide valid results, first the individual components and systems have to be verified to be operating properly (see Develop & Utilize Construction Checklists). This includes Start-up and Testing, Adjusting and Balancing (TAB). The GSA PM must coordinate start-up and installation activities with the GSA Fire Protection Engineer's role in occupancy permitting to include testing for compliance with life safety and code requirements.

Test Data Records

Test data records capture outcomes of functional performance testing including test data, observations and measurements. Data may be recorded using photographs, forms or other means appropriate for the specific test. Test data records shall include, but not limited to, the following information:

- Test reference (number, specific identifier, etc.)
- Date and time of test

- First test or retest following correction of an issue
- Identification of the systems, equipment and/or assemblies under test including location and construction document designation
- Conditions under which the test was conducted (i.e. ambient conditions, capacity/ occupancy, etc.). Tests shall be performed under steady-state and stable conditions.
- Expected performance
- Observed performance including indication of whether or not this performance is acceptable
- Issues generated as a result of the test
- Dated signatures of those performing and witnessing the test

Test Issues & Follow-up

The functional performance tests are the heart of the commissioning process and they are also the most difficult and time consuming. System troubleshooting is a critical function of the CxA. As inspecting and testing proceed, despite the team's best efforts, the CxA will find a number of items that do not appear to work as intended. There will be a certain amount of system retesting that will be performed by the CxA because of system deficiencies during the initial testing. In order to assure success, the GSA PM shall allow some time in the schedule and money in the budget for retesting. The GSA PM shall be apprised that issues resolution and associated financial implications are a common point of contention between parties.

If equipment or systems are found to be malfunctioning, these problems shall be documented and listed in the Issues Log for team resolution. The Issues Log must be very clear about the test, system(s) involved, and tracking of the problem as it is corrected. Both the amount of retesting paid for by GSA versus the amount paid by the contractor and/or designer, as well as the parameters for which parties are responsible for correcting deficiencies shall be very clearly spelled out in the contracts.

Hold Commissioning Team Meetings & Report Progress

Consistent, regular Commissioning Team meetings are essential to maintain the progress of the project and the momentum of the commissioning process. The schedule of meetings shall be defined, documented and included in appropriate

bid documents during the Design Stage (monthly construction phase Cx Team meetings are recommended). Team members at meetings must be authorized to make commitments and decisions for their respective parties. The typical agenda for construction phase Commissioning Team meetings shall include items such as previous action items, outstanding issues, schedule review, new issues, etc. In addition to regular meetings, the CxA is responsible for preparing monthly Commissioning Process Reports during the construction phase. These reports shall include at a minimum the following information:

- Progress & status report along with look-ahead
- Identification of systems or assemblies that do not perform in accordance with Owner's Project Requirements
- Results from latest version of the Issues Log (importance, cost & measures for correction)
- Test procedures & data
- Deferred & seasonal tests (and reason for deferring)
- Suggestions for enhancements which will improve the commissioning process and/ or the delivered facility. The Commissioning Progress Reports shall be distributed to the entire Commissioning Team.

Conduct Owner Training

An important step in the commissioning process is ensuring that GSA Operating Personnel are properly trained in the required care, adjustment, maintenance and operations of the new facility equipment and systems. It is critical that operations and maintenance personnel have the knowledge and skills required to operate the facility to meet the Owner's Project Requirements. Training shall specifically address:

- Step-by-step procedures required for normal day-to-day operation of the facility
- Adjustment instructions including information for maintaining operational parameters
- Troubleshooting procedures including instructions for diagnosing operating problems
- Maintenance and inspection procedures
- Repair procedures including disassembly, component removal, replacement and reassembly
- Upkeep of maintenance documentation and logs
- Emergency instructions for operating the facility during various nonstandard conditions and/or emergencies
- Key warranty requirements

Commissioning Agent Role in Training

Because of the Commissioning Agent's in-depth knowledge of the design intent and building systems, it is important to have the CxA intimately involved in the training. The CxA is responsible for facilitating the entire owner training process. This process begins in the Design Stage by assuring that appropriate levels of training are planned and included in the specifications. The CxA maintains a system-based as opposed to component-based focus in the training to ensure that operating personnel understand the interrelationships of equipment, systems and assemblies. The CxA also reviews agendas and material developed by the contractors in advance of the trainings for quality, completeness and accuracy. The CxA shall also attend a number of the key training sessions to evaluate effectiveness and suggest improvements in the delivery of the material.

Training Timing & Requirements

The majority of training shall be done during the construction phase prior to substantial completion. Some systems and assemblies may require ongoing training during occupancy and post-construction. The exact systems, subsystems, equipment and assemblies that require training as well as the required number of hours of training are spelled out in the project specifications. The CM utilizes attendee sign-in sheets to verify that the training was delivered to the intended staff. The instruction shall be given during regular work hours (for all shifts) on such dates and times that are selected by the GSA Project Manager. The instruction may be divided into two or more periods at the discretion of the GSA PM. It is highly recommended that all trainings be videotaped. Videotaping trainings allows for future reference of the material and training of new employees down the road. The team may also wish to consider DVDs in lieu of videotapes for reasons of longevity and convenience. The Contractor shall be required to provide the GSA PM with an edited draft version of the taped training sessions (generally within seven days), which include all aspects of the operation, inspection, testing and maintenance of the systems. The CxA, GSA Operating Personnel and GSA Technical Experts will review the videotape and provide the Contractor with comments. The Contractor will then resubmit an

edited final version of the tape (generally within seven days of receipt of comments).

Instructor Qualifications

The instructor shall have received specific training from the manufacturer regarding the inspection, testing and maintenance of the system provided. The instructor shall train the Government employees designated by the Contracting Officer in the care, adjustment, maintenance and operation of the new facility equipment and systems. Each instructor shall be thoroughly familiar with all parts of the installation. The instructor shall be trained in operating theory as well as practical operation and maintenance work.

Turnover Commissioning Record

It is critical to understand that commissioning documentation is developed throughout the project & turned over before substantial completion. Commissioning documentation turned over at this stage of the project is a result of a well thought out documentation plan and collection of information throughout all of the project phases. The following matrix outlines necessary documentation of the commissioning process by project phase in order to complete the Commissioning Record.

Commissioning Record Document

Document	Phase Started	Developed/Provided By
Commissioning Plan	Planning	GSA PM
Commissioning Plan Appendices		
A. Owner's Project Requirements	Planning	GSA PM
B. Basis of Design	Design	A/E
C. Commissioning Specifications	Design	A/E/CxA
D. Design Review	Design	CxA
E. Submittal Review	Design	CxA
F. Test Procedures	Design	CxA
G. Issues Log	Construction	CxA
H. Construction Checklists	Construction	CxA/Construction Contractor
I. CxA Site Visit & Cx Team Mtg. Minutes	Construction	CxA
J. O&M Review	Construction	CxA
K. Training Documentation	Construction	CxA/Construction Contractor
L. Warranty Review	Construction	CxA
M. Test Data Reports	Construction	CxA/Construction Contractor
Summary Report	Construction	CxA
Recommissioning Management Manual	Construction	CxA/GSA PM

The Commissioning Record shall include a brief summary report that includes a list of participants and roles, brief building description, overview of commissioning and testing scope, and a general description of testing and verification methods. For each piece of commissioned equipment, the report shall contain the disposition of the Commissioning Agent regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas:

- 1) Equipment meeting the equipment specifications,
- 2) Equipment installation,
- 3) Functional performance and efficiency,

- 4) Equipment documentation, and
- 5) Operator training.

Re-commissioning Management Manual

The Re-commissioning Management Manual provides guidance and establishes timelines for re-commissioning of building systems and components. The format of the Re-commissioning Management Manual will closely parallel the Commissioning Plan for the facility.

Post-Construction Stage

Systems, assemblies, equipment and components will tend to shift from their as-installed conditions over time. In addition, the needs and demands of facility users typically change as a facility is used. The Post-Construction Stage allows for the continued adjustment, optimization and modification of building systems to meet specified requirements.

The objective of the Post-Construction Stage is to maintain building performance throughout the useful life of the facility. The active involvement of the Commissioning Agent and the Commissioning Team during initial facility operations is an integral aspect of the commissioning process.

Commissioning activities during Post-Construction include issues resolution, seasonal testing, and delivery of the Final Commissioning Report, performing a post-occupancy review with the Customer Agency and developing a plan for re-commissioning the facility throughout its life cycle.

Perform Deferred & Seasonal Testing

Due to weather conditions, not all systems can be tested at or near full load during the Construction Phase. For instance, testing of a boiler system might be difficult in the summer and testing of a chiller and cooling tower might be difficult in the winter. For these reasons commissioning plans shall include offseason testing to allow for testing of certain equipment under the best possible conditions. In addition to seasonal testing, several systems may have been deferred during the initial testing for a number of reasons including prerequisite activities not complete, phased occupancy issues and improper testing

conditions. The commissioning team must use the Issues Log as a guide during Post-Construction Stage to complete all deferred testing.

Requirements for deferred and seasonal testing must be clearly defined in the contract documents as it will require some contractor personnel to return to the site after the project is completed. It is also necessary to withhold money for this activity in addition to the traditionally withheld warranty items.

Re-inspect/Review Performance before End of Warranty Period

During the first year of the building's operation it is important to assure that the performance of the facility is maintained, particularly before the warranty period expires. At 10 months in to a 12 month warranty period, operation of system and components is critically reviewed by CxA, Owner and CM to identify any items that must be repaired or replaced under warranty. This review is based on warranty items and continued performance with Owner's Project Requirements. Discrepancies between predicted performance and actual performance and/or an analysis of any complaints received may indicate a need for minor system modifications. The CxA documents the results and forwards recommendations to Owner and CM for resolution.

The GSA PM shall be cognizant of the impacts of a phased occupancy, if applicable, on the warranty period and make necessary adjustments for review and inspection. Proper maintenance programs, training and familiarization of the systems by the new operating staff are important to support Post-Construction commissioning. For example, a standard method of recording and responding to complaints must be in place and used consistently. As equipment and controls are replaced throughout the maintenance program, calibration and performance must be checked, documents revised and any changes or new equipment data sheets included in the operations & maintenance manuals.

Ongoing training includes refresher training of existing personnel, training of new personnel and training of all personnel on newly installed equipment or revised operating procedures.

Complete Final Commissioning Report

During Post-Construction, the Commissioning Agent is responsible for delivering a Final Commissioning Report. This document is additive to those items detailed in the “Turnover Commissioning Record” section. The Final Commissioning Report shall include at a minimum:

- A statement that systems have been completed in accordance with the contract documents and that the systems are performing in accordance with the final Owner’s Project Requirements document
- Identification and discussion of any substitutions, compromises or variances between the final design intent, contract documents and as-built conditions
- Description of components and systems that exceed Owner’s Project Requirements and those which do not meet the requirements and why
- Summary of all issues resolved and unresolved and any recommendations for resolution
- Post-Construction activities and results including deferred & seasonal testing results, test data reports and additional training documentation
- Lessons learned for future commissioning project efforts
- Recommendations for changes to GSA standard test protocols and/or facility design standards (i.e. GSA P-100, etc.)

The Final Commissioning Report will serve as a critical reference and benchmark document for future re-commissioning of the facility.

In addition, the CxA is responsible at this stage to assure the A/E’s update to the CAD As-Built drawings is completed.

Final Satisfaction Review with Customer Agency

As one of the benefits of commissioning is to increase occupant and user satisfaction, it is important that the GSA PM lead a final satisfaction review with the Customer Agency. This review shall occur at one year after occupancy (according to GSA’s Facility Performance Evaluation Process). Minimum attendees shall include the Commissioning Team and other selected Customer Agency representatives. The purpose of this review is to obtain honest, objective and constructive feedback on what worked well throughout the commissioning process and what the Commissioning Team could have done better. The group shall be focused on identifying root causes and proposing corrective action for future projects. Specific discussion topics may include:

- Owner’s Project Requirements
- Systems selected for commissioning

- Coordination issues
- Commissioning budget and costs
- Commissioning schedule relative to project schedule
- Occupant comments/complaints
- Documentation issues
- Lessons learned

The GSA PM takes the lead on documenting this session in a formal lessons learned report. This information will be an important input to future projects.

Re-commission Facility Every 3-5 Years

At this stage of operation a considerable investment has been put into assuring the facility operates as intended. Understanding that systems tend to shift from their as-installed conditions over time due to normal wear, user requests and facility modifications, it is strongly recommended that Customer Agencies consider re-commissioning facilities every 3-5 years. A facility re-commissioning program serves to assure operational efficiency and continued user satisfaction. Maintaining good O&M and occupant complaint records is key to continued re-commissioning efforts. Re-commissioning shall generally include:

- Establishing that original basis of design and operation is still appropriate for use, occupancy, tenant agencies and GSA goals, and modify the operations/controls sequencing as appropriate for optimum operations
- Reviewing and benchmarking key systems operations/performance against the Basis of Design
- Evaluating envelope tightness/pressurization by infrared or other methods
- Performing energy analysis
- Recommending repairs/modifications to optimize building performance.

It is important to recognize that at 3-5 years after occupancy, the GSA PM will likely not still be involved with a particular project. Therefore, the Customer Agency will take the lead on facility re-commissioning. Re-commissioning shall include Commissioning Agent services. While there are obvious benefits of familiarity, the Customer Agency may or may not bring back the project Commissioning Agent. Re-commissioning is not part of the original CxA's contract, and therefore the Customer Agency must procure these services through a RFQ/RFP process at the time of re-commissioning.

References:

1. BSR/ASHRAE/IES Standard 202P, *Commissioning Process for Buildings and Systems, First public review, August 2012.*
2. The Building Commissioning Association, *Best Practices in commissioning Existing Buildings*, 8/18/08.
3. GAS Public Building Service, *The Building Commissioning Guide*, April 2005.