Building Commissioning Association

NEW CONSTRUCTION

BUILDING COMMISSIONING

BEST PRACTICES

Including

BCxA Essential Attributes updated May 2018

Contents

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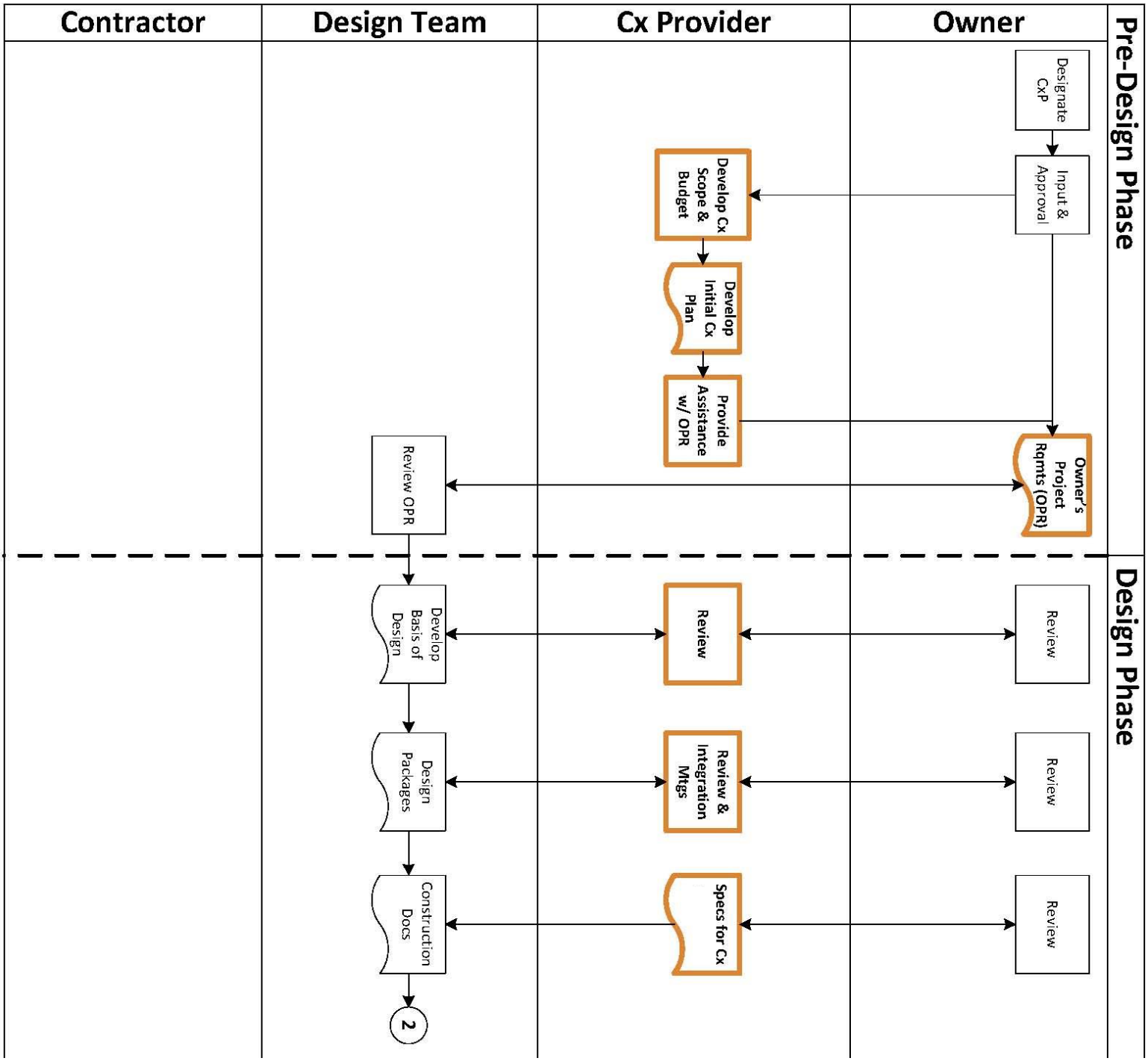

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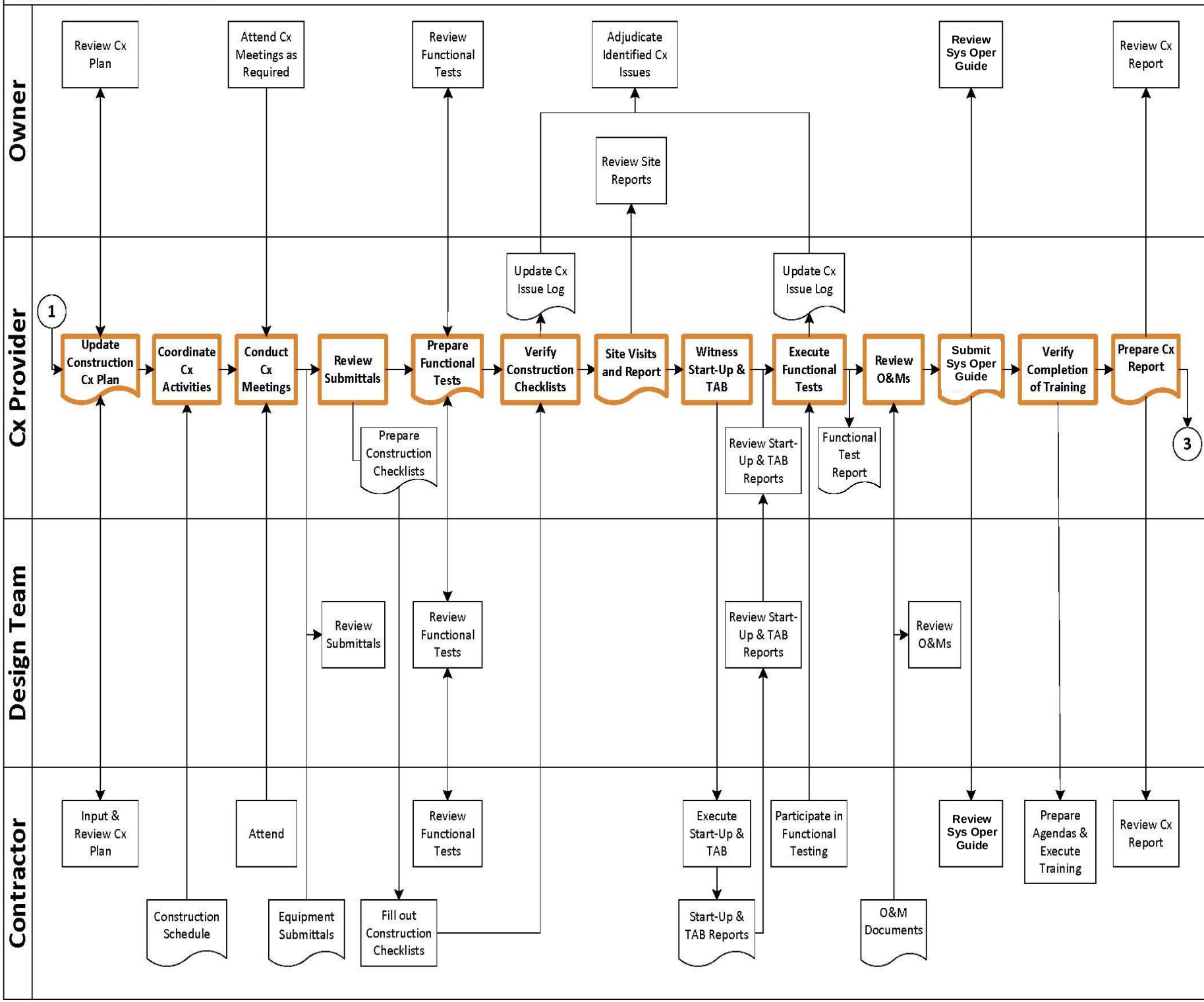
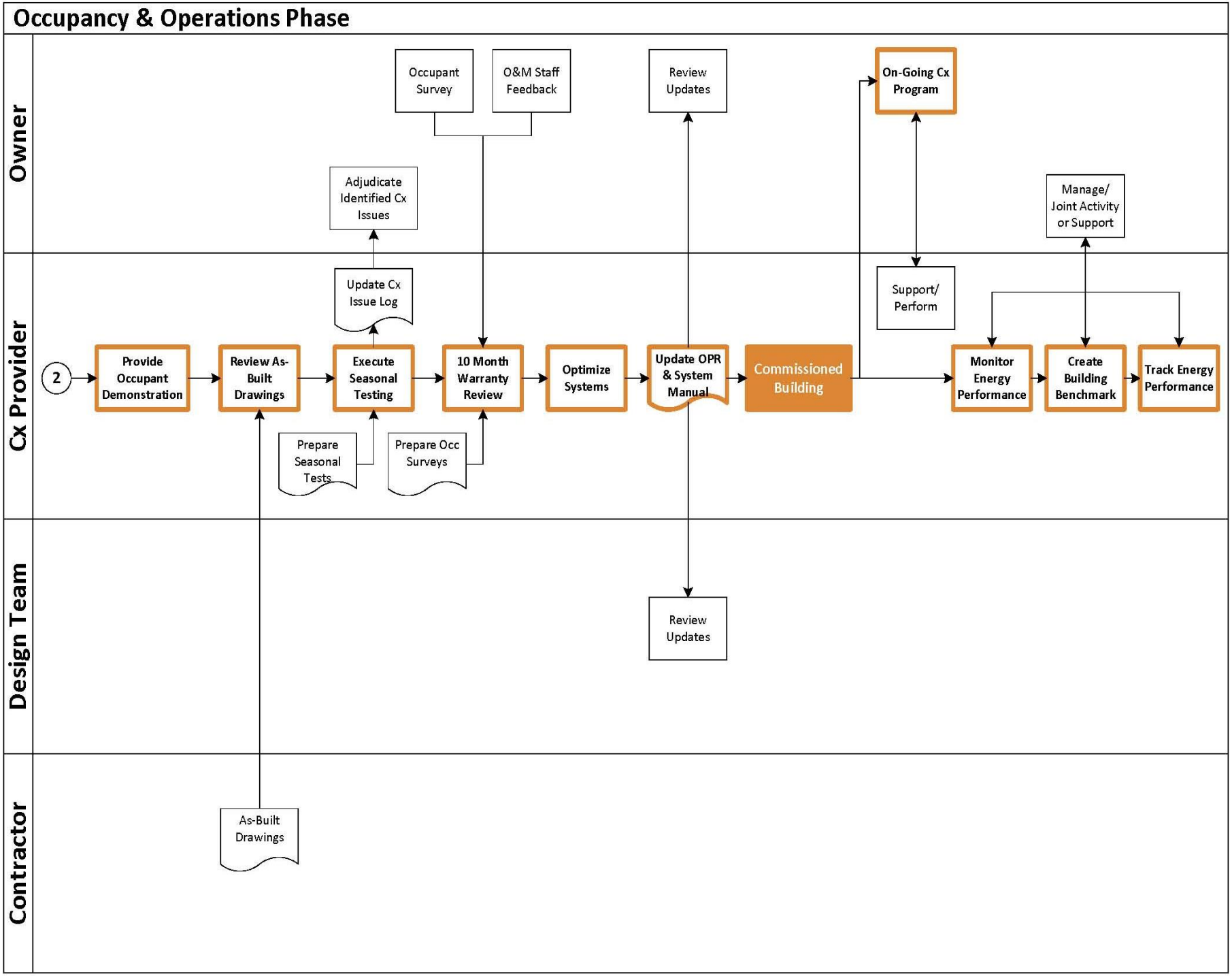


Building Commissioning Association
BCxA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1. INTRODUCTION

Overview and Purpose

The Building Commissioning Association (BCxA) is composed of owners, engineers, architects, contractors, commissioning providers and users of commissioning services in their day-to-day operations. The BCxA is the only organization dedicated exclusively to building commissioning as its sole purpose. Members represent a broad cross-section of interests and are associated with many sectors of the facilities and construction community. The BCxA states that the basic purpose of commissioning is “to provide documented confirmation that building systems and assemblies are designed, installed and function in compliance with criteria set forth in the Project Documents to satisfy the owner's operational needs.”

New construction commissioning has matured as an industry practice. Codes, standards, guidelines, protocols and certifications have been created to define and clarify the commissioning process. Some fundamental elements of the process have been enhanced, modified, redefined or de-emphasized and new elements added. Some elements are not well implemented or understood. Subsequently, the BCxA felt that writing a best practices document would help distill the long list of guidelines and longer list of tasks into primary activities that represent the ideal commissioning process, applicable to most building types and projects.

The BCxA is committed to defining best practices in the building commissioning industry and to providing documents, such as example templates for RFQ/P, commissioning plans and specifications, that describe these practices and offer practical solutions to issues in the industry. Best Practices documents that communicate sound processes and a generally accepted ideal standard of care have been developed by the BCxA for both existing buildings and new construction. These Best Practices have been shown over time to be justified in a wide variety of systems and building types.

The definition of best practice creates a benchmark against which the market can gauge quality and professionalism. This Best Practice allows the BCxA and other organizations to objectively evaluate commissioning initiatives, processes, guidelines, training curricula and certifications, etc. It facilitates improved and more broadly adopted implementation of high quality building commissioning

processes. This document complements the BCxA Essential Attributes, which set a minimum and essential standard, while the Best Practice helps define top quality.

Scope and Level of Detail

The New Construction Building Commissioning Best Practice is intended to cover a general new construction commissioning process that is applicable to most building systems and assemblies. It is process driven, with allowable flexibility for unique conditions, and where a practice seems unclear by its varied application, more detail is given. For example, the document will give a general statement about the best practice of functional testing but won't delve into the particulars of the best practice functional testing of any specific piece of equipment or assembly. The document describes the recommended process of commissioning but does not offer guidance on the systems that should be commissioned or the specific rigor that should be applied since those are project-specific. The only notable exception is the specific addressing of building automation system and controls because they have been and continue to be the focus of most if not all building commissioning projects. Details of most of the elements and means and methods for their application can be found in the documents referred to in the online BCxA Knowledge Center. In many places the Best Practices indicate who is expected to be responsible for the completion of a given task. Where absent, the responsible party may be from any qualified member of the Cx Team.

Best Practice

The term "best practice" generally refers to the best possible way of doing something. There is no single universally "best" way to apply commissioning in all circumstances. "Best" is taken in context of reasonable cost and schedule limitations; desires for objectivity and rigor; differing building and equipment types, project size, and complexity. The best practice is done to achieve optimal results and is thus a benchmark for quality and professionalism.

Development Process

The BCxA's New Construction Building Commissioning Best Practice was developed and refined over a two-year period by a volunteer Task Force of BCxA practitioners selected for their deep commissioning experience and commitment to the commissioning profession. Each member of the Task Force brings extensive knowledge, practical skills and solutions-based abilities resulting from practice in a wide range building types, with a variety of owners and project teams. They represent a cross-section of regions across the USA.

The Task Force utilized the following primary reference sources: ASHRAE Guideline 0-2005, Guideline 1.1-2007, the BCxA Essential Attributes and Valuable Elements of Commissioning. The Task Force had the latitude to vary from these and other reference documents, but was essentially consistent with them. Other reference sources included the BCxA Commissioning Handbook, BCxA training curriculum, and the National Institute of Building Science (NIBS) Whole Building Design Guide.

To inform the development of the Best Practices, in 2008, the BCxA surveyed its members to identify major issues of concern, areas for improvement, observations about where the industry is going, and where potential pitfalls or roadblocks for the advancement of commissioning for new construction might exist. The BCxA Task Force analyzed each concern or issue and identified best practice solutions which were then included in the Best Practices. This original survey as well as the industry concerns and issues along with the solutions identified for each are available by download here.

The Task Force used their experience as commissioning professionals to create not simply a merging of the referenced sources, but a listing of those elements in the resources that are considered to represent best practice. Even if a practice was rarely done, it may have been considered a best practice and is therefore included. If a practice is very innovative and effective, but expensive and difficult to implement with readily available technology, it is not listed as a best practice, although in future best practice versions it may be. Some practices recommended in some of the guidelines were not considered best practice, although they could be valuable in certain situations and are only mentioned in a qualified manner in the BCxA's Best Practice document.

The Task Force's Best Practice was sent out to the BCxA membership at large for their review and input. The Task Force responded to comments and

incorporated those that they felt were warranted. The BCxA Board of Directors then approved the final version in 2011.

2015 Revision

In 2015 the BCxA Best Practices Committee completed a major revision of the New Construction Best Practices utilizing essentially the same process. Newer guidelines and standards were referenced such as ASHRAE Std. 202-2013. The revised version includes added detail and minor clarifications to various Cx processes and deliverables. The revised version was approved by the BCxA Board in September 2015.

2018 Revision

The BCxA and APPA completely updated and rewrote their *Building Commissioning Handbook* in 2017. That effort illuminated some areas that warranted updating and revising in the BCxA New Construction Best Practices. These changes were made by the Best Practices Committee and approved by the BCxA Board in January of 2018. A version showing the changes from the 2015 version is available upon request.

Updates

As the commissioning industry matures and practicing professionals continue to gain experience, the list of best practices set forth here will be refined and modified. Accordingly, suggestions through respective commissioning organizations are invited.

Reference Guide

The 2018 Best Practices document has been integrated with a library of well over 100 documents, templates and resources from BCxA's Knowledge Center and many other online documents outside BCxA. These resources provide additional details and examples of best practice. This integration created essentially a reference guide to the Best Practices. These sources originated with the document templates previously on the BCxA website and were edited, enhanced and added to by the Best Practices Committee. Throughout the Best Practices there are over 100 unique words and phrases that are underlined hyperlinks. Each hyperlink will link the user to a small webpage containing links to specific documents in BCxA's Knowledge Center or other relevant sources from which the practitioner can obtain additional information on the term or issue.

Each document from the BCxA Knowledge Center is not necessarily considered absolutely ‘best practice,’ but the Best Practice Committee did review and edit each of the documents making reasonable effort to ensure the documents represented good, if not best practice in their opinion. Documents referred to outside the BCxA Knowledge Center were reviewed, but of course were not edited. BCxA does not warrant that every document and its contents linked to are approved or recommended by BCxA. Only the Best Practices themselves carry that endorsement. The Reference Guide links are not considered comprehensive, providing one or two sources for each specific term out of the many that are available on the internet.

Acknowledgments

The Best Practice Task Force acknowledges the thoughtful and essential contributions made by members of the BCxA who provided invaluable input and comments on each draft. Listed alphabetically, the original Task Force consisted of: Mark Miller, Bruce Pitts and Karl Stum (chairs) and Stacy Abbott, J.R. Anderson, Laurie Catey, Brian Hennig, A.J. Kindya, Nathaniel Mostajo, Todd Rindlisbaker, John Villani and Evan Wyner.

The 2015 Best Practices revision was completed by J.R. Anderson, Wade Berner, Daniel Boyton, Doug Cansdale, A.J. Kindya, David Lewis, Jack Schirpke, Robert Smith and Karl Stum with technical editing by Diana Bjørnskov. The large task of reviewing and editing the library of over 100 referenced documents to become part of the Reference Guide was completed by J.R. Anderson, Wade Berner, Doug Cansdale, Kevin David, A.J. Kindya, David Lewis, Kevin Knueven, Jack Schirpke, Karl Stum, Gary Sturgill and Mike Watts.

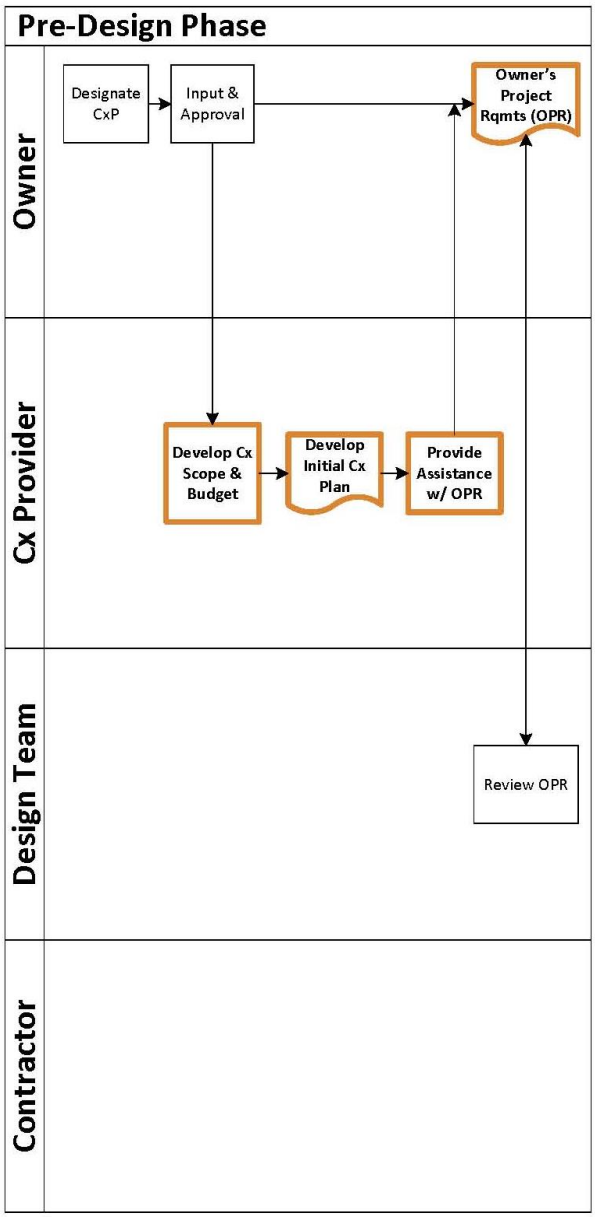
The 2018 Revision was completed in January 2018 by the Best Practices Committee with significant review and input by the BCxA International Board.

2. PRE-DESIGN PHASE

2.1 Introduction/Overview

Commissioning ideally begins in the pre-design phase.

The Pre-Design Phase lays the groundwork for the project, defines the plan for commissioning, and begins the essential team building process. During this phase the design and commissioning teams are assembled and the Owner's Project Requirements (OPR) and the building program are developed. All decisions made in ensuing phases should be made with reference to the OPR.



2.2 Objectives

- ⇨ **Identify** the Commissioning Team
- ⇨ **Develop** the OPR
- ⇨ **Define** the initial commissioning scope and budget
- ⇨ **Develop** the initial commissioning plan
- ⇨ **Verify** that the building program is consistent with the OPR.
- ⇨ **Integrate** commissioning into the overall project delivery process and begin building the Commissioning Team.

2.3 Commissioning Team

- Owner/ Owner's representative
- Commissioning Provider (CxP)
- Design team
- Operating and Maintenance Personnel (when available)
- Construction Team Personnel (when available)
- Building End User Representatives (when available)

2.4 Pre-Design Activities

A. **Owner designates a party to act as their project representative** for commissioning related activities.

B. **Owner selects /designates a Commissioning Provider** for the project.

1 **The CxP directs the overall commissioning process** and makes the final recommendations to the owner regarding functional performance of the commissioned building systems. BCxA Essential Attribute

2 **The CxP is an objective, independent advocate for the Owner.** BCxA Essential Attribute

If the CxP's firm has other project responsibilities, or is not under direct contract to the Owner, a conflict of interest exists. Wherever this occurs, the CxP discloses, in writing, the nature of the conflict and the means by which the conflict shall be managed.

3 In addition to having excellent written and verbal communication skills, **the CxP has current engineering knowledge and extensive hands-on field experience regarding** BCxA Essential Attributes:

a. Building systems

b. The physical principles of building systems performance

c. Building systems start-up, balancing, [functional] testing and trouble shooting

d. Operation and maintenance procedures

e. The building design and construction process

C. Develop the OPR for the Project

1 The OPR defines the expectations, goals, benchmarks and success criteria for the project. The OPR must be developed with significant owner input and ultimate approval. The CxP ideally assists the Owner (and at minimum reviews results) in identifying the facility's requirements regarding all building systems and assemblies, relative to such issues as design and construction processes and schedules, energy efficiency, sustainability, indoor environmental quality (temperature, humidity, ventilation, lighting, connection to outdoors), safety, security, component and assembly quality, reliability, durability, flexibility, redundancy and

cost, staff training, operation and maintenance, documentation, commissioning rigor, monitoring and ongoing commissioning and other Owner directives.

2 An effective OPR incorporates input early in the project from the Owner, design team, operation and maintenance staff and end users of the building and is updated throughout the project.

   a. An effective OPR is developed utilizing accepted methods for obtaining input (e.g. questionnaires, or Nominal Group Technique, workshops, etc.)

   b. The elements of an effective OPR are at minimum verifiable and at best include success criteria.

D. **Define the commissioning scope, schedule and budget.** The design schedule should include the commissioning activities. The commissioning scope identifies the systems and assemblies to be commissioned and outlines the activities and the rigor of the commissioning process.

   For each project, **the commissioning purpose and scope shall be clearly defined in the CxP contract**. BCxA Essential Attribute

   The CxP recommends the commissioning roles and scope for all members of the design and construction teams and that the scopes are clearly defined in:

   1 Each design consultant's contract

   2 The construction manager's contract

   3 General Conditions of the Specifications

   4 Each division of the specifications covering work to be commissioned

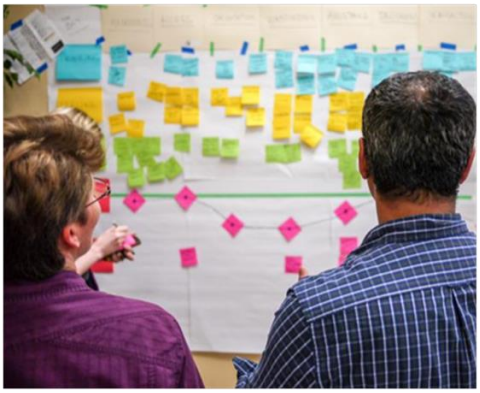
   5 **The specifications for each system and component for which the supplier's support is required** BCxA Essential Attribute

E. **Incorporate commissioning into the project budget and schedule.** Incorporate commissioning into the project budget and schedule. The project budget should be adequate to support the commissioning activities and the construction schedule should provide sufficient time to accomplish all commissioning activities. The commissioning scope should include provisions for the Occupancy and Operations phase activities which are sometimes overlooked by the team focused on the design and construction phases.

F. **Develop the Commissioning Plan.** **Each project is commissioned in accordance with a written commissioning plan that is updated as the project progresses**. BCxA Essential Attribute
The commissioning plan:

1 Identifies the systems to be commissioned
2 Defines the scope of the commissioning process
3 Defines commissioning roles and lines of communications for each member of the project team
4 Estimates the commissioning schedule

The Commissioning Plan developed during the Pre-Design Phase should address in detail the development of and the ongoing management of the OPR, the development of the Basis of Design (BOD) and the design review process. Other elements of the Plan are normally developed in later phases. The Cx plan should be updated at each formal step of design and at the start of construction.



G. **Develop the Issues Log format and protocols.** The Issues Log formats for the design phase and construction phase should be developed to facilitate the documenting, tracking and resolution of commissioning related issues. Issues Logs are managed by the CxP and typically contain at a minimum a detailed description of the issue, date identified, party responsible for corrections, issuing party and completion status. **All findings are documented and distributed as they occur.** BCxA Essential Attribute

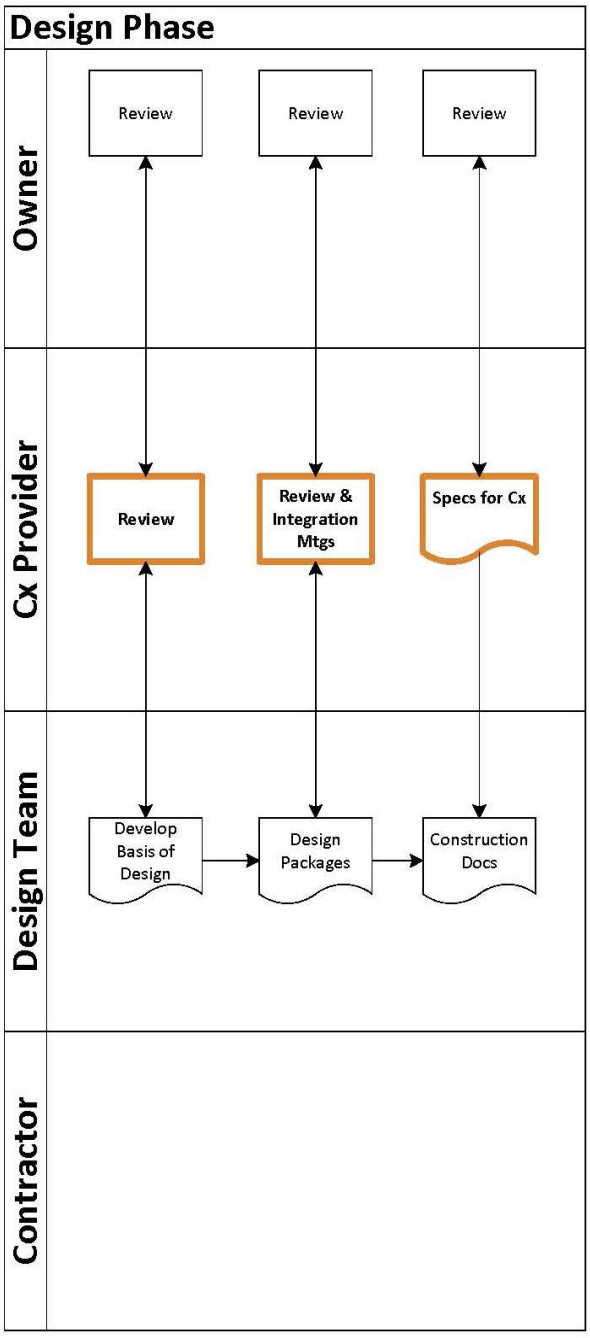
H. **Review the Building Program.** The Commissioning team reviews the building program documents and determines whether they are consistent with and support the Owner's Project Requirements.

I. **Prepare the Pre-Design Phase Commissioning Report.** At the conclusion of the Pre-Design Phase a report is developed by the CxP that compiles the commissioning related documentation from the Pre-Design Phase.

3. DESIGN PHASE

3.1 Introduction/Overview

During the design phase, the commissioning prc confirms that design documentation (plans, specifications, Basis of Design (BOD), etc.) are consistent with each other, include commissioni requirements and meet the Owner's Project Requirements (OPR).



3.2 Objectives

- ⇨ **Communicate** the commissioning requireme other project team members.
- ⇨ **Verify**, through review, that the design documentation is consistent with the OPR ar BOD.
- ⇨ **Ensure** that commissioning requirements ar included in the construction documents.
- ⇨ **Build Engagement** and cooperation among project team members.

3.3 Commissioning Team

Owner Representative

User Representatives

Commissioning Provider (CxP)

Design Team

Construction Team (engaged when known)

3.4 Design Phase Activities

A. **Update the commissioning plan and scope.** If a plan has not been developed, the CxP creates one as described in the pre-design phase covering the Design Phase in final detail and summarily the Construction Phase. Updates to the plan during design should include more detail about the construction phase responsibilities, process, new project team members, communication protocols and schedule for Construction. Later in Design the Cx Plan is fully developed for Construction. Any needed additions to the CxP's scope should be made at this time.

B. **Conduct a design phase commissioning kick-off meeting** to review the commissioning plan and activities with the commissioning team.

C. **The Design Team develops a Basis of Design (BOD)**

D. **Review the OPR and BOD for completeness and clarity (by the CxP).** The OPR and BOD should also be included as an attachment to the construction documents for Contractor information, without being binding, except for requirements also found in the drawings and specifications.

E. **Ensure the OPR and BOD documents are updated** and in alignment with each other to reflect any Owner-approved changes made during the design process.

F. **The CxP provides focused design checklists** for the design team to facilitate important, but sometimes forgotten design concepts and items that encourage better practice. Consider the following or other appropriate checklists:

    1 State of CA design review checklists NRCC-CXR-02-E thru -04-E, (http://www.energy.ca.gov/2015publications/CEC-400-2015-033/appendices/forms/NRCC/)

    2 Or NIST (https://www.wbdg.org/ffc/va/design-review-checklists)

G. **Perform commissioning-focused reviews** of the design submissions using experienced qualified personnel of the CxP or Owner.

    1 Design reviews shall be documented by comment statements appropriate for the level of completeness of the design. The CxP is respectful in wording comments.

    2 In summary, design reviews will accomplish the following:

        a. Confirm general quality and completeness of the documents.

        b. Review for discipline-specific compliance with the OPR for commissioned systems and assemblies

c. Confirm the BOD is accurate and aligns with the OPR.

d. Confirm that it is feasible to commission the design.

e. Confirm adequate O&M documentation and training requirements.

3 The commissioning reviews focus on verifying that the OPR and BOD are met relative to facilitating the commissioning process, including training and O&M documentation, and ongoing commissioning – in particular, for example for HVAC systems, that the reviews confirm that there are adequate equipment access, test ports, monitoring capabilities and points, and control features. Reviews also verify that energy-efficiency, operation, control sequences, maintenance, training and O&M documentation requirements are consistent with the OPR and BOD.

As part of verifying the OPR and BOD, at least for commissioned equipment, the reviews should include reviewing for general document quality, identifying areas that are inconsistent or unclear or that won't meet the OPR or that don't represent good practice.

4 Of particular importance is to perform a thorough review resulting in specific control logic and control systems integration requirements necessary to fully implement the sequences of operation. This should be completed prior to late construction documents when it becomes more difficult to make changes.

5 Prior to construction documents phase design packages being submitted for review, the CxP encourages and facilitates integration meeting(s) held to coordinate systems and equipment that interact with each other such as M&V monitoring needs between the HVAC and electrical disciplines, interplay with the HVAC building automation system (BAS) and fire alarm and emergency power, lighting and access control with the BAS and integration of the building enclosure with the HVAC system.

6 The ideal number and timing of reviews varies from project to project. Larger and more complex projects warrant more reviews. The CxP should discuss with the Owner the advantages and disadvantages of more review (potential impacts to the design schedule, costs, benefits, etc.). Many if not most projects warrant the following reviews with back-checks:

- 100% Schematic Design (primarily a review of the BOD)
- 100% Design Development
- 50% and 90% Construction Documents

7 Fewer reviews may be warranted for smaller or simple projects. Larger or more complex projects may warrant a concepts review and additional reviews in design development.

8 The design team should provide written response to each of the design review comments. These responses should be returned to the CxP and issues resolved, with the CxP, design team and Owner all understanding the agreed upon path forward on each comment. This resolution should be documented prior to the design team moving significantly into the next design phase in an Issues Log managed by the CxP.

9 At the next design submission, the CxP back-checks the comments from the previous review, i.e., confirms that the agreed-upon resolution for each comment from the previous review has been incorporated into the plans and specifications.

H. **The CxP confirms that facility operator training requirements are in compliance with the OPR and are included in the construction documents.**

1 Training requirements should be thorough, including training hours required for all systems and assemblies summarized in one section for reference and tracking. Detailed equipment-specific training agendas should be required that provide for trainees to be instructed to the level of detail appropriate for their job responsibilities. For typical operators this would include an overview and specific training on the equipment features, operation, safety, maintenance, alarms and troubleshooting. The O&M manual should be utilized in the training. This should include requirements for the CxP to provide training on the purpose and use of the Systems Operations Guide. Requirements should be included for verifying training completion and its effectiveness. Video recordings provided to the owner of most trainings is considered best practice. Refer to Section 4 for additional detail about training delivery.

I. **Develop commissioning specifications** to ensure that commissioning requirements are included in the construction documents. The CxP creates or confirms the following:

1 In the specifications, fully explain all contractor-related commissioning responsibilities. For clarity and information, summarily list the CxP, their subconsultants, and other non-contractor team member responsibilities without detailed explanation (Construction Manager (CM), Owner, design team). Clearly delineate between the contractor responsibilities and the responsibilities of the rest of the team.

2 Include requirements for:

a. Submittals

b. Commissioning Meetings

c. Commissioning schedule development

d. Construction checklist development and execution

e. Functional test procedure format and development

f. Startup process

g. Contractor's measuring instrument calibration requirements

h. Test readiness confirmation

i. Functional testing process - including management, execution and documentation

j. Balancing report review and validation of readings in the field with the contractor

k. Issues log process

l. Deferred functional testing

m. Training verification

n. O&M manuals

o. Contractor's Project Turnover Documentation requirements

3. *Sampling*. The specifications should include specifics as to the allowed or required sampling. Sampling may be considered for the following commissioning tasks: design review, submittal review, field installation observation, construction checklist verification, functional testing of multiple identical pieces of non-critical or non-life safety equipment and assemblies, trend log analysis and operation and maintenance (O&M) manual review. The owner should clearly define the desired level of sampling, objectivity and rigor in the CxP request for proposals (RFP). CxPs should identify their level of sampling in their proposals, when not explicitly dictated in the RFP.

4. *Appropriately defining and following the testing scope is probably the single most critical success factor for meeting the performance objectives of the commissioning process.* Include an equipment-specific functional testing scope for each piece equipment or type of assembly or system. Include test form

content and format requirements, test rigor, any sampling allowed, trending requirements, etc. Functional testing scope and rigor should be defined by listing the modes to be tested, under what conditions and give the acceptance criteria. Identify what testing is and is not part of the formal commissioning process, i.e., delineate between commissioning functional testing and contractor quality control and other testing specified elsewhere in the specifications (e.g., duct and pipe pressure testing, generator load bank testing, etc.)

5. Normally require the manual testing rigor to include testing each sequence in the sequence of operations and other significant modes, capacity and load modulation extremes, interlocks, control strategies and alarms and packaged control features, sequences and elements and control during loss and restoration of power and fire alarm events. Refer to Section 4 for detail of the test procedure forms.
6. Require that 100% of all larger, more complex, process critical or life-safety equipment be individually tested. Testing only a sample of some equipment or assemblies might be appropriate for some projects where such equipment or assemblies are small in physical size or importance, are numerous and are not complex or critical for process or life-safety.
7. Require for systems that are monitored through a building automation system, that trending of systems is conducted as part of the functional testing after manual testing is complete. Trends shall confirm proper operation of all major control loops, equipment staging and time of day scheduling, etc. Compile and submit the trend graphs as documentation.
8. When determined to be warranted by the CxP, provide as supplemental information to bidders one or more representative functional test forms and construction checklists to illustrate the scope and rigor expected and allow the contractor to more knowledgeably bid the work.
9. Coordinate with the design team on other sections of the specifications that mention functional testing or commissioning-related activities so they are consistent with the formal commissioning sections. Cross reference between sections.
10. Include how completion of commissioning activities relates to occupancy permits and project closeout milestones.
11. Project Documentation. With the Owner, the CxP determines the scope of the project documentation to be provided to the Owner (Systems Operations Guide,

the Commissioning Record and the Contractor's Project Turnover Documentation) and confirms the requirements are included in the contract documents.

The Systems Operations Guide provided by the CxP should include salient information for operating the facility that are not found in the O&M manuals, including such things as the BOD (if current, else include short updated design narratives), system single-line flow diagrams, final set points, diagnostic instructions, recalibration and OCx guidelines and emergency and maintenance shutdown procedures.

The Commissioning Record provided by the CxP should include all formal Cx documentation other than meeting minutes and communications.

The Contractor's Project Turnover Documentation provided by the Contractor should include OPR, BOD, record documents, approved submittals, including controls and balancing, change orders, O&M manuals, preventive maintenance procedures linked electronically directly from the O&M table of contents, warranties and training materials.

These three compilations are submitted to the owner in an electronic folder, file and bookmarked structure with enough granularity to allow ready access to all data. The CxP, and optionally the A/E or qualified Owner personnel, approves their general content and functionality and confirms delivery to the Owner.

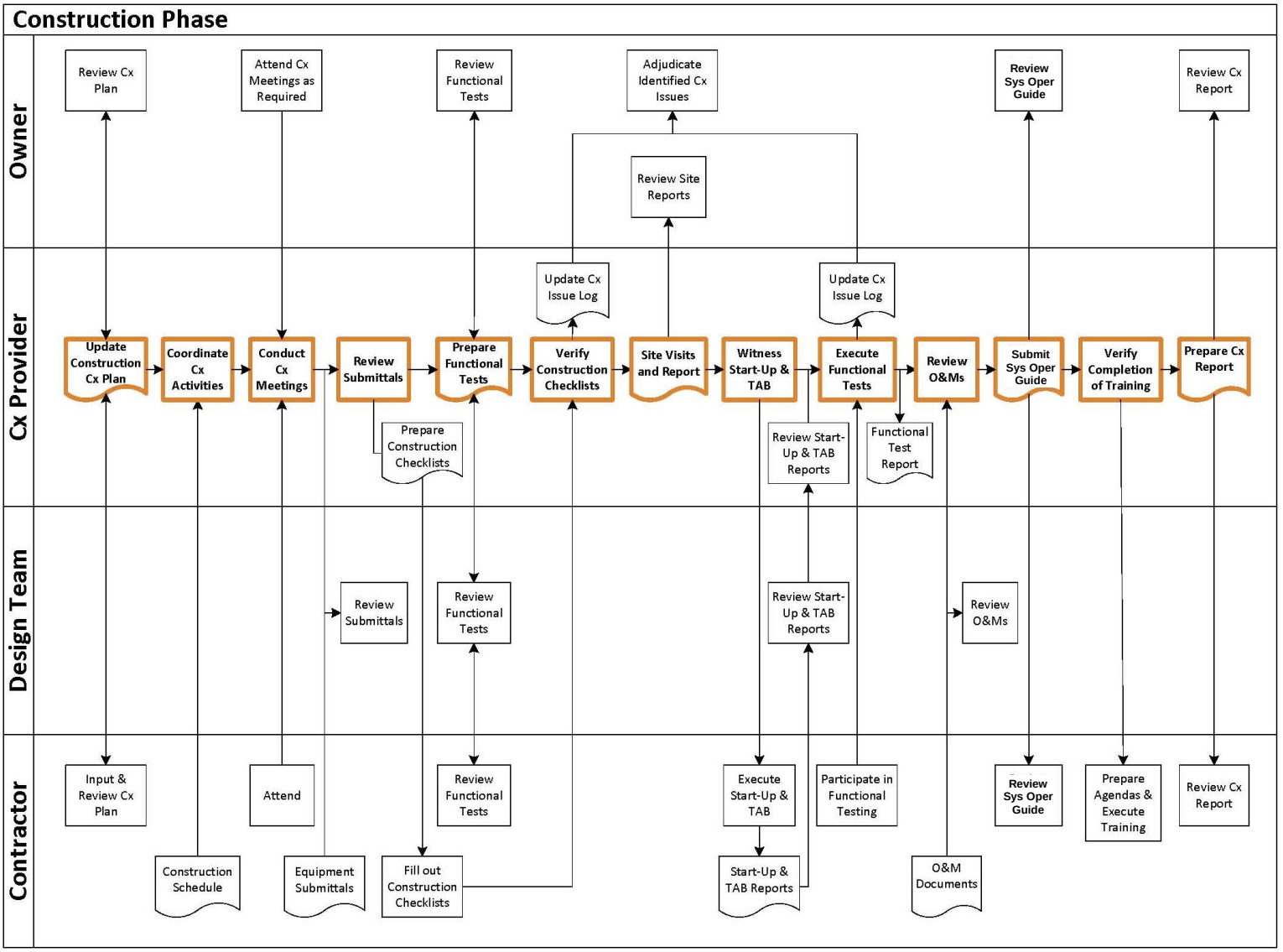
12. The CxP works to build cohesiveness and cooperation among the project team by clearly communicating the commissioning process and the role of each party.

J. **Near the end of Design, the Cx Plan and design documents should be updated to be consistent with each other.** The Cx Plan should include the details of the responsibilities and roles of the Contractor as well as those of the CxP, Owner and Designers which may or may not be articulated in detail in the specifications. The Cx Plan should also include the activities and responsible parties for the Occupancy Phase.

K. **The commissioning plan, OPR and BOD should be provided to the contractor** during bidding for information, not obligation, as a supplement to the construction documents to augment the commissioning specifications.

4. CONSTRUCTION PHASE

4.1 Introduction/Overview



Successful construction phase commissioning is a well-coordinated quality assurance and control process that encompasses installation, start-up, functional testing, documentation and training. During the construction phase the commissioning team works to ensure that equipment, systems and assemblies are properly installed, integrated, and operating in a manner that meets the Owner's Project Requirements (OPR). Functional testing and documentation provide valuable performance benchmarks, acceptance criteria and a baseline for the future operation and ongoing commissioning of the facility.

4.2 Objectives

- ⇨ The Commissioning Plan (Cx Plan), the OPR, and BOD are updated.
- ⇨ Commissioning team members understand their roles and responsibilities for the construction phase commissioning activities.
- ⇨ Equipment, systems, and assemblies are properly installed, maintainable, and functioning properly as required to meet the OPR.
- ⇨ The operations and maintenance (O&M) personnel are provided with complete and proper systems operating documentation.
- ⇨ The O&M personnel, and occupants as needed, are properly trained. Training materials and documentation compiled to facilitate repeating training and training new staff in the future.

4.3 Commissioning Team

Owner's representative

Commissioning Provider (CxP) and sub-consultants

Design team

Construction Management Representative

Contractors

Building occupant or user group representatives

Personnel responsible for the building's O&M

4.4 Construction Phase Commissioning Activities

A. **Updates to the Cx Plan, BOD, and the OPR** to reflect changes made to the project by their original creators.

B. **Each project should be evaluated and when sufficiently advantageous to the success of the project, utilize electronic and cloud-based Cx management processes.**

C. **Integrate the Commissioning Schedule into construction schedule.** The CxP works with the contractor to integrate the Cx activities into the construction schedule, with adequate time to complete all commissioning activities.

D. **Conduct construction phase commissioning kick-off meeting.** The kick-off meeting is most effectively held when the contractors have mobilized to the site. All commissioning team members are introduced, the Cx plan is reviewed, with roles and responsibilities are reviewed, and the expectations of schedule and deliverables are documented.

E. **Review submittals.** The CxP reviews submittals of commissioned equipment concurrently with the design team in a coordinated process that all parties agree to. Reviews normally focus on issues relative to commissioning facilitation.

F. **Hold construction phase controls integration meetings.** One or more construction phase integration meetings between the CxP, the designers, the controls contractor, and other appropriate subcontractor(s), and the building operator are held after the controls and fire alarm and emergency power systems submittal review and prior to submittal approval. The goals of this meeting are to facilitate resolution of review comments; verify that the controls system and system sequences are complete, verifiable, coordinated and meet the OPR; and that fire alarm and emergency power systems are coordinated with the controls and each other. Follow-on meetings may be required with the equipment programmers to ensure they understand the project requirements.

G. **Develop the master list of commissioned equipment, systems and assemblies.** This list may also be utilized by the owner for O&M purposes.

H. **Develop list of special requirements.** During construction, the CxP, or the Contractor with CxP (with Owner review) should prepare from the

specifications a list of the required warranties, spare parts and closeout documentation. This should be updated as the project progresses. The completed list should be accepted by the owner, engineer of record, or CxP as a condition of final acceptance.

I. **Complete development of project specific Construction Checklists.** The checklists should be prepared utilizing the approved construction submittals and installation manuals to make the checklists specific to the installed equipment. Construction Checklists should be given to the contractor for review and comment prior to beginning installation. The CxP should create these documents (or approve them if created by others, prior to their use).

J. **Develop functional testing procedures and test data forms.** The functional test procedure forms are developed, usually by the CxP (or approved by them if developed by others), after the controls submittals and other commissioned systems and assemblies are approved. The contractor and designers review the forms and provide comments back to the CxP. The functional test procedures forms are completed and given to the contractor as soon as possible after acceptance of the submittals, prior to controls programming and equipment start-up. Contractors run equipment through these tests using the forms to verify that the systems are ready for later functional testing with the CxP. Test procedures are developed uniquely for each project and are composed of repeatable, step-by-step narrative procedures and include the test prerequisites and set up conditions, the test process of perturbing or observing the system or set points, the expected outcomes, the acceptance criteria and a place to record the results. Refer to Section 3.4 for details of the scope of the tests.

K. **Maintain Issue Log.** The CxP maintains an Issues Log to document and track commissioning items that do not comply with the construction documents and OPR.

L. **Conduct regularly scheduled commissioning coordination meetings.** The number of meetings varies widely depending on the commissioning scope and the project complexity. These periodic construction-phase commissioning meetings should continue throughout construction with major efforts at key periods of the construction and commissioning. However, the CxP scope should include enough commissioning

coordination meetings to keep the CxP involved in the project to help the contractors follow the Cx Plan.

M. **Construction Checklists.** The contractor thoroughly executes the Construction Checklists and other required startup and checkout documentation and submits to the CxP and other required parties in a timely manner, so they can be used to aid confirming test readiness.

N. **Conduct regularly scheduled site visits.** Site visits by the CxP are often held in concert with the construction or commissioning coordination meetings. Objectives of the commissioning site visits are to verify completion of construction checklists, quality control and proper installation early and to prevent systemic problems when there are numerous similar or identical equipment or devices. For example, the building enclosure commissioning lead could review enclosure mock-ups prior to full installation.

O. **Assist project team with resolution of issues.** **The commissioning provider provides constructive input for the resolution of system deficiencies.** BCxA Essential Attribute
The CxP verifies that the resolution is compatible with the contract documents

P. **Review Start-up Reports.** The CxP reviews contractor and special agency equipment start-up and quality control testing documents and witness selected or critical startups and contractor quality control tests (e.g., duct and piping system pressure tests, generator load bank tests, etc.).

Q. **CxP reviews requests for information and change orders** of commissioned equipment. Comment as warranted to maintain the OPR.

R. **Review the Testing, Adjusting and Balancing (TAB) plan and report.** The TAB plan and report should be reviewed by the CxP concurrently with the designer and comments and recommendations provided to the designer. The plan should be approved prior to any TAB work. The TAB report is typically verified by the CxP witnessing repeatability of original TAB field measurements through sampling techniques prior to or during functional testing as appropriate.

S. **Confirm Functional Test Readiness.** The CxP confirms test readiness through the construction phase activities (field observation, review of start-up reports, construction checklists and the Issues Log, observation of control system and equipment operation, including trending and when required review of contractor's pre-tests of system operation) or receiving a letter of test readiness prior to beginning the functional testing program to ensure that the functional testing process will run smoothly. Providing functional test procedures to the contractor early and having them be required to execute the tests on their own prior to formal functional testing with the CxP is generally recommended for most systems.

T. **Coordinate, execute and document functional testing.** The functional testing program objectively verifies that the building systems perform interactively in accordance with the Project Documents. Written, repeatable test procedures, prepared specifically for each project, are used to functionally test components and systems in all modes of operating conditions specified for testing. **These tests are documented to clearly describe the individual systematic test procedures, the expected systems response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion.** BCxA Essential Attribute

1 The commissioning team is responsible for executing all functional tests. The CxP-designated Cx Team member coordinates, witnesses and documents the functional tests as defined in the commissioning plan and specifications.

2 Perform deferred functional testing during Occupancy and Operations phase as required so tests are performed during proper weather or operating conditions.

3 Systems and assemblies that fail to meet the passing criteria shall be retested until accepted by the commissioning team.

4 When a central building automation system (BAS) is part of the project, trend logs of temperature, flow, current, status, pressure, set

points etc., as well as any automatic fault detection and diagnostic features are utilized to confirm proper operation over time of all systems possible. This augments the manual functional testing.

5 When critical data is not available through a BAS, monitoring and recording of performance data is accomplished by using stand-alone data loggers.

U. **CxP reviews contractor as-built documents, warranties and O&M Manuals. Verify that the operations & maintenance manuals comply with the contract documents.** BCxA Essential Attribute This as-built review is not a validation (unless so scoped), but a summary review providing some assurance they were developed.

V. **Compile the Construction Phase Commissioning Report.** Every commissioning project is documented by the CxP with a commissioning report that includes:

1 An Executive Summary

2 Brief project background, building description, commissioning scope, process and schedule of activities

3 An evaluation of the operating condition of each of the systems at the time of functional test completion

4 Deficiencies (issues) that were discovered and the measures taken to correct them

5 Uncorrected issues and deficiencies

6 Functional test procedures and results

7 **Description and estimated schedule of required deferred [functional] testing.** BCxA Essential Attribute

8 List of commissioning field activities

9 Record of operator training completion

10 Record of delivery to owner of required project documentation (confirmation by Owner or CxP)

In addition, as best practice the following should be part of the Construction Phase Commissioning Report or included in the Final Commissioning Report provided later in the Occupancy and Operations Phase:

a) OPR
b) BOD
c) Design phase reviews
d) Cx plan
e) Cx specifications
f) Cx submittal reviews
g) Field reports
h) Completed construction checklists
i) Start-up reports
j) Results of warranty phase activities (deferred testing, near-warranty-end review, baselining, optimization, etc.)

The report should be provided in electronic copy format unless requested otherwise by the Owner.

W. **Finish Preparing the Systems Operations Guide.** The Systems Operations Guide prepared by the CxP whose preparation began during design, provides the information needed to understand and properly operate, the building systems and assemblies and is submitted to the Owner. Refer to the Design Phase, Section 3, for its contents.

X. **Prepare the Commissioning Record.** The CxP assembles documentation of the Cx process and submits to the Owner. Refer to the Design Phase, Section 3, for its contents.

Y. **Assemble the Contractor's Project Turnover Documentation.** The contractor compiles and submits required project documentation, as defined in Section 3 and submits to the Owner in granular electronic folder, file and bookmarked structure. The CxP or qualified Owner personnel confirm the functionality, general content and delivery.

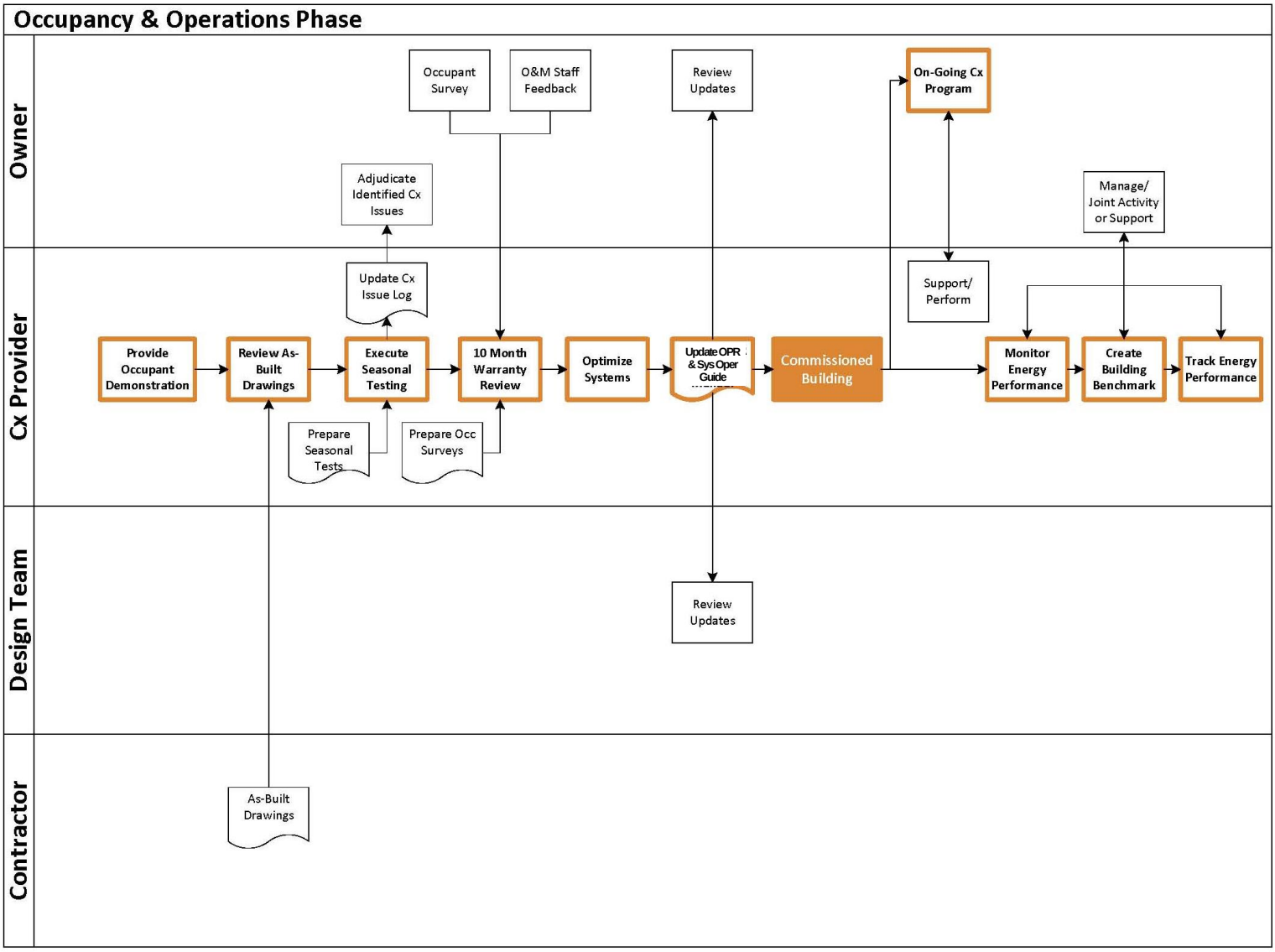
Z. **Verify training of the owner O&M personnel and end users. Verify that the training for the owner's operating staff is conducted in accordance with the project documents.** BCxA Essential Attribute

The key objective of the owner's operating staff training is to convey knowledge and skills required to effectively and efficiently operate the

facility. This includes an understanding of the OPR and BOD as well as training on the purpose and use of the Systems Operations Guide. The CxP reviews the contractor's submittals of the training content, materials, and instructor qualifications to verify that the training will meet the requirements of the commissioning plan and the contract documents. Trainees complete a basic training evaluation form providing feedback regarding effectiveness. The owner ideally should have the CxP participate in key training sessions, including usage of the Systems Operations Guide, and/or use other methods to confirm that the training was delivered effectively. Additional training details are found in Section 3.

5. OCCUPANCY AND OPERATIONS PHASE

5.1 Introduction/Overview



The Occupancy and Operation Phase normally begins at Substantial Completion when the building is turned over to the Owner, though some construction phase activities may still be in process. In the Occupancy and Operations Phase all uncompleted activities from the construction phase are finished (project closeout activities) as well as the long-term processes for ensuring building performance over time being developed and put into place (ongoing maintenance and performance activities).

5.2 Objectives

- **Facilitate** the continued engagement of the Cx team and verify the completion of outstanding Cx issues.
- **Complete** any seasonal and deferred functional testing and O&M staff training and occupant orientation.
- **Complete** systems and commissioning documentation.
- **Evaluate** project success.
- **Optimize** building performance.
- **Develop and begin implementation** of a plan for commissioning the building over time (Ongoing Commissioning).
- **Survey** occupants, formally check in with operations staff and assess issues.
- **Benchmark** energy performance and evaluate and track performance over time.

5.3 Commissioning Team

Owner/ Owner's Representative
Operation Personnel

5.4 Occupancy and Operations Activities

Chronologically the Occupancy and Operations Phase activities are grouped into Completion of Project Closeout and Ongoing Performance. These activities are crucial and entail the CxP transferring their engagement from the capital projects (construction) group of the Owner to the O&M group where the CxP encourages the O&M group to incorporate all valuable activities from the list in this section.

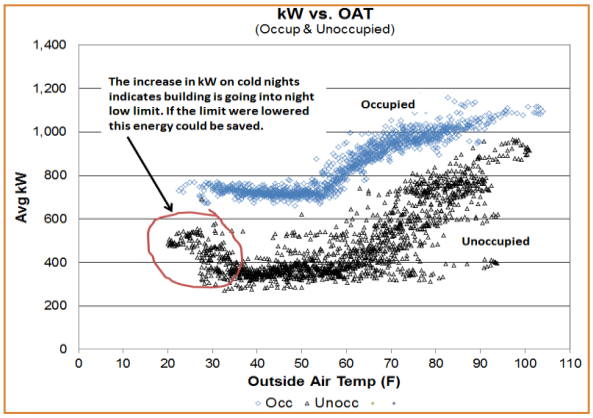
Completion of Project Closeout Activities

A. **Provide timely addressing and tracking** of performance problems and incomplete items from the Cx Issues Log. The CxP encourages Owner project managers and contractors to address issues before the project loses sufficient momentum to effectively deal with them.

B. **Conduct and verify completion of outstanding O&M personnel training.** According to the contract documents, the Contractor conducts deferred training of the O&M personnel. CxP or Owner personnel evaluate the effectiveness of the training program and make a recommendation as to the need for supplemental training.

C. **Complete seasonal and deferred functional testing.** When thorough testing of loading, staging and capacities can't be completed during the initial functional testing, testing is deferred to the appropriate season or load condition during occupancy. This testing is accomplished by or under the direction and approval of the CxP.

D. **Conduct periodic check-ins with Operation and Maintenance staff.** Two to six times during the first year, as appropriate for the facility, the CxP contacts the operations staff and building manager and asks about building operations and performance issues related to commissioned equipment. The CxP provides



technical support and assists within their contract scope to remedy issues or forward them on to the Contractor or design team.

E. **Optimize systems.** In the course of their occupancy phase activities of trend log review and deferred and seasonal testing, the CxP identifies opportunities for fine-tuning system performance such as optimizing schedules, sequences, and set-points, in addition to other perceived improvements and changes to accommodate actual building occupancy and use. The CxP may assist in implementation of the changes, which may need to be made after the Contractor's warranty period is over to prevent voiding warranties.

F. **Conduct an occupant survey.** The project team presents a survey to the occupants 7 to 9 months after move-in, but before the Building Operations Review to confirm that a satisfactory indoor environment related to commissioned systems has been achieved for a substantial majority of the occupants. Surveys should address the following elements: thermal comfort, indoor air quality, lighting and day lighting, and acoustical quality. Additional elements may be evaluated when dictated in the Owner's Project Requirements.

G. **Perform a Building Operations Review.** The CxP conducts an on-site review of building operations about 10 months after substantial completion, typically near the end of the warranty period. The Building Operations Review includes a review of the results of the Occupant survey and previous check-ins with the O&M personnel, a review of work orders related to commissioned systems and a review of alarm and complaint logs and review of selected trend logs of known problem areas and other critical areas to confirm proper performance and equipment operation. Issues identified during the review are documented along with a proposed solution and identification is made of the responsible party for correction, as well as any need for additional training. Issues under warranty of the original construction contract are provided to the contractor for resolution. The Commissioning Report is updated to reflect the Building Operations Review and other changes or additions that occur during the Occupancy and Operations Phase.

H. **Compile a Final Commissioning Report.** Commissioning documentation elements listed under the Construction Phase Commissioning Report section

above that were not provided then are now assembled by the CxP and issued to the Owner.

I. **Evaluate project success.** Key representatives from the project design, construction, commissioning and operations and maintenance teams participate in a lessons-learned workshop. The workshop or meeting openly discusses and documents project successes and identifies opportunities for improvements for future projects relative to the commissioning process. Key metrics and performance indicators of the OPR are evaluated against actuals.

J. **Update the Project Documentation Systems Operations Guide.** The Systems Operations Guide should be updated with deferred functional testing, deferred training material and appropriate documentation from any other changes. Operations personnel are informed how to keep the Systems Operations Guide up to date as changes occur throughout the life of the building.

Ongoing Performance and Persistence Activities

Ongoing performance activities are strongly recommended and help building performance persist.

K. **Provide an Occupant User's Guide.** The Guide describes the special elements and features in the building occupants will be interacting with. Include instructions for the use and interactions with these systems for occupants. Cover the following systems when included in the Cx scope: Lighting controls (schedules, occupancy sensors, daylighting controls, user overrides), thermostats and user adjustments, comfort complaint procedures, time of day HVAC schedules by floor, night set back impacts on temperature, overrides, occupancy sensors tied to HVAC, air diffuser design, special room pressure controls, automatic window shades, energy dash board, etc. Provide orientation and demonstration to occupants relative to elements of the building systems and the assemblies they interact with.

L. **Develop a preventive maintenance plan.** With input and support from the Owner and from utilizing the recommendations in the O&M manuals and industry resources develop a realistic preventive maintenance schedule for

commissioned systems and assemblies. This is an enhancement, as necessary, of the links to the PM procedures provided by the Contractor in the O&M manuals that were submitted as part of the Contractor's Project Turnover Documents. When the Owner is developing the PM plan, the CxP should provide input into how appropriate calibrations and elementary tests could be integrated into the PM plan.

M. **Develop and begin implementation of the Ongoing Commissioning Program.** The Ongoing Commissioning Program includes the repeating of selected device span and sensor accuracy verification and functional testing portions of the commissioning process on a periodic basis, or ongoing monitoring and trending with associated automatic or manual fault detection diagnostics, or a combination of these methods. The magnitude, order and frequency of the re-testing of components and systems are dictated by the likelihood of performance degradation. The program should include continuous monitoring of the more energy intensive systems and those more prone to performance problems.

   Benchmarking building, system or end-use energy performance and developing correlations to appropriate parameters, such as outside air temperature, should be part of the ongoing Cx Program. Long-term energy monitoring should be put in place and a method for utilizing the correlations should be employed that alerts the Owner when equipment, systems and the building are not performing to energy expectations.

N. **Implement new construction commissioning when appropriate.** As changes or additions are made to the building the new construction commissioning process is applied.

O. **Update the OPR and Systems Operations Guide.** Throughout the life of the building as alterations are made or as building usage changes, the OPR and Systems Operations Guide may need to be updated in order to reflect current conditions and requirements.

DEFINITIONS

Acceptance. Acceptance is a formal action to declare that some aspect of the project meets defined requirements, thus permitting subsequent activities to proceed.

Architect/Engineer (A/E). See Design Team.

Automated Fault Detection. A technology that monitors components, equipment and/or systems and recognizes when they are failing, they have failed or when environmental conditions have drifted outside optimal capability range. The technology may potentially optimize operation and/or notify personnel, possibly ensuring timely identification and correction of operating and service issues.

Back-Check. A back-check is a verification that an agreed upon solution to a design comment has been adequately addressed in a subsequent design review.

Basis of Design (BOD). A document that records concepts, calculations, decisions and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. Also known as the Design Criteria.

Benchmarks. Benchmarks are the comparison of a building's energy usage to other similar buildings and to the building itself. Developing standards and goals for energy management is a good way to motivate people to improve towards the goal of optimal energy performance. For example, ENERGY STAR Portfolio Manager is a frequently used and nationally recognized building energy benchmarking tool.

Building program. A document prepared by the owner or architect that describes the facility's space and function requirements.

Commissioning Provider (CxP). An entity identified by the Owner who plans, schedules and coordinates the commissioning team to implement the Commissioning Process.

Commissioning Plan. A document that outlines the organization, schedule, allocation of resources and documentation requirements of the commissioning process.

Commissioning Record. All formal Cx documentation other than meeting minutes and communications provided to the Owner in a granular electronic folder, file and bookmarked structure.

Commissioning Process. A quality-focused process for enhancing the delivery of a project and includes verifying and documenting that the facility and its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the Owner's Project Requirements.

Commissioning Report. A document recording the activities and results of the commissioning process. Usually developed from the final Commissioning Plan with all of its attached appendices.

Commissioning Review. The commissioning review is a collaborative review of the design professionals design documents for items pertaining to the following: owner's project requirements; basis of design; operability and maintainability (O&M) including documentation; functionality; training; energy efficiency, control systems' sequence of operations including building automation system features; commissioning specifications and the ability to functionally test the systems. This review is not a holistic "peer" review.

Commissioning Specifications. The contract document that details the objective, scope and implementation of the commissioning process as developed in the Commissioning Plan.

Commissioning Team. A team comprised of the CxP, Owner, A/E, Construction Manager/General Contractor, Contractors, maintenance and operations personnel, and occupants. Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action.

Construction Checklists. list of items that verify that equipment is on-site, ready for installation, correctly installed, set up, calibrated, functional and ready for formal functional testing.

Contract Documents. The documents binding on parties involved in the construction of this project (drawings, specifications, change orders, amendments, contracts, Cx Plan, etc.).

Contractor. The general contractor's or subcontractor's authorized representative.

Construction Documents. Construction documents include all building plans, specifications, general conditions of the contract and supporting documents (such as change orders and submittals) used for the completion of a construction project.

Construction Manager (CM). The owner's representative managing the construction project. Often the construction manager and the general contractor are the same entity.

Construction Team. A team comprised of Construction Manager/General Contractor, sub-contractors and equipment vendors & suppliers.

Data Logging. The monitoring and recording of temperature, flow, current, status, pressure, etc. of equipment using stand-alone' data recorders.

Deferred Functional Testing. Tests that are performed after substantial completion, due to ambient load or occupancy conditions, not allowing a thorough test during the initial testing period.

Design Team. The professionals (architects, engineers and consultants) responsible for developing the project's design concepts, interim and final drawings, specifications and basis of design.

Functional Test. The testing of the dynamic function and operation of components, equipment and systems using manual (direct observation) and monitoring (data-logging/trending) methods.

Functional Test Procedure. A written protocol that defines methods, steps, personnel, and acceptance criteria for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

Issues Log. A formal and ongoing record of problems or issues – and their resolution – that have been raised by members of the commissioning team during the course of the commissioning process.

Lessons Learned Workshop. A workshop conducted to discuss and document project successes and identify opportunities for improvements for future projects.

Manual Test. Testing using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the 'observation').

Monitoring. The recording of parameters (temperature, flow, current, status, pressure, etc.) of equipment operation using data loggers or the trending capabilities of control systems.

Nominal Group Technique. A formal, structured brainstorming process used to obtain the maximum possible ranked input from a variety of viewpoints in a short period of time. The typical approach is a workshop session where a question is presented, the attendees record their responses individually on a piece of paper, the individual responses are recorded on a flip chart without discussion in a round robin fashion, all of the responses are discussed, and then the participants rank their top five responses.

Ongoing Commissioning. The application of commissioning related process activities on an ongoing basis to ensure that operations are being met to support the ongoing improvement of system performance. The Ongoing Commissioning Plan details how these activities and goals will be achieved.

Operations and Maintenance (O&M) Manual. O&M manuals describe key components of each system or piece of equipment and explain how they should be operated and maintained for optimum performance.

Owner's Project Requirements (OPR). A written document that details the requirements of a project and the expectations of how it will function. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

Owner's Representative or Project Manager (Owner). The contracting and managing authority for the Owner who oversees the design and/or construction of the project.

Peer Review. A formal in-depth review separate from the commissioning review processes. The level of effort and intensity is much greater than a typical commissioning facilitation or extended commissioning review.

Project Turnover Documentation (by Contractor). OPR, BOD, record documents (plans & specs), approved submittals, including controls and balancing, change orders,

O&M manuals, preventive maintenance procedures linked electronically directly from the O&M table of contents, warranties and training materials. Provided to the Owner in a granular electronic folder, file and bookmarked structure.

Sampling. Performing observation, review, testing or other verification on only a fraction of the total number of identical or near identical pieces of equipment, drawings, events, etc. Sampling techniques include random statistical sampling and less formal professional judgment methods.

Seasonal Testing. See Deferred Testing.

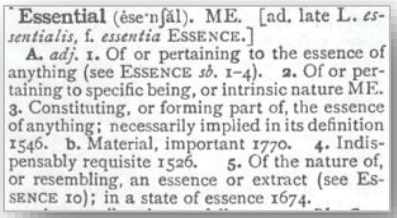
Systems Manual. A compilation used by other Cx Guidelines (such as ASHRAE and USGBC) that includes the Systems Operations Guide, the Cx Record and the Contractor's Project Turnover Documentation referred to in the Best Practices.

Systems Operations Guide. Salient information for operating the facility that are not found in the O&M manuals, including such things as the BOD (if current, else include short updated design narratives), system single-line flow diagrams, space environmental requirements, final set points, diagnostic tools, trends and reports instructions, recalibration and OCx guidelines and emergency and maintenance shutdown and restart procedures. The Guide is provided by the CxP in a granular electronic folder, file and bookmarked structure.

Trending. Monitoring over a period of time with the building automation system.

Verification. The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the Owner's Project Requirements or other project documents.

Warranty Period. Period of time in which the contractor is responsible for equipment repairs following turnover to the owner. The warranty period is defined in the construction contract.



Essential (ėse·nʃăl). ME. [ad. late L. *essentialis*, f. *essentia* ESSENCE.]
A. *adj.* 1. Of or pertaining to the essence of anything (see ESSENCE *sb.* 1–4). 2. Of or pertaining to specific being, or intrinsic nature ME. 3. Constituting, or forming part of, the essence of anything; necessarily implied in its definition 1546. b. Material, important 1770. 4. Indispensably requisite 1526. 5. Of the nature of, or resembling, an essence or extract (see ESSENCE 10); in a state of essence 1674.

BCXA ESSENTIAL ATTRIBUTES 2018 UPDATE

The BCxA believes that diverse and creative approaches to commissioning benefit the discipline of building commissioning[1] and its clients. Therefore, this document focuses on identifying critical commissioning attributes and components, rather than attempting to dictate a rigid commissioning process. The attributes described herein are called "essential", because the BCxA believes that they are, in fact, essential to every effective commissioning process. Applying additional commissioning best practices may enhance the process or add commissioning value. However, the BCxA believes that not including any of these Essential Attributes renders a process that becomes something other than formal commissioning[2]. As a result, all BCxA members agree in writing to incorporate all of the Essential Attributes of Building Commissioning into every project for which they serve as a project's Commissioning Provider, as defined in this document.

In order to clarify context for these Essential Attributes, and because the scope of commissioning varies between projects, the BCxA defines the basic purpose of commissioning as follows: It is the BCxA's premise that, "The basic purpose of building commissioning is to provide documented confirmation that building systems[3] function in compliance with criteria set forth in the Project Documents[4] to satisfy the Owner's operational needs. Commissioning of existing systems may require the development of new functional criteria in order to address the owner's current systems performance requirements."

APPENDIX

The Essential Attributes of building commissioning are:

1. The Commissioning Provider (CxP)[5] is in charge of the commissioning process and makes the final recommendations to the owner regarding functional performance of the commissioned building systems.
2. The CxP is an objective, independent advocate of the Owner. If the CxP's firm has other project responsibilities, or is not under direct contract to the Owner, a conflict of interest exists. Wherever this occurs, the CxP discloses, in writing, the nature of the conflict and the means by which the conflict shall be managed.
3. In addition to having good written and verbal communication skills, the CxP has current engineering knowledge, and extensive hands-on field experience regarding:
    - Building systems commissioning,
    - Technical knowledge of building systems,
    - Building systems start-up, balancing, testing and troubleshooting,
    - Operation and maintenance procedures,
    - The building design and construction processes,
    - Automated control systems and control logic.
4. For each project, the commissioning purpose and scope are clearly defined in the CxP contract.
5. The CxP recommends the commissioning roles and scope for all members of the design and construction teams be clearly defined in:
    - Each design consultant's contract,
    - The construction manager's contract,
    - General Conditions of the Specifications,
    - Each division of the specifications covering work to be commissioned, and
    - The specifications for each system and component for which the suppliers' support is required.
6. Each project is commissioned in accordance with a written commissioning plan that is updated as the project progresses. The commissioning plan:
    - Identifies the systems to be commissioned,
    - Defines the scope of the commissioning process,

- Defines commissioning roles and lines of communications for each member of the project team, and
- Estimates the commissioning schedule.

7. On new building commissioning projects, the CxP reviews systems installation for commissioning related issues throughout the construction period.
8. All commissioning activities and findings are documented as they occur. Issues are tracked through resolution and acceptance. These reports are distributed as they are generated and included in the final report.
9. The functional testing program objectively verifies that the building systems within the commissioning scope of work perform interactively in accordance with the Project Documents. Written, repeatable test procedures, prepared specifically for each project, are used to functionally test components and systems in all modes of operating conditions[6]. These tests are documented to clearly describe the individual systematic test procedures, the expected systems response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion.
10. The commissioning authority provides constructive input for the resolution of system deficiencies.
11. Every commissioning project is documented with a commissioning report that includes:

    - An executive summary including an overview of the implemented commissioning process, the systems commissioned, the major findings and the operating condition of the systems at the completion of functional testing,
    - Issues that were discovered and the measures taken to correct them,
    - Unresolved operational issues that were accepted by the owner, along with related recommendations,
    - Operational and ongoing commissioning recommendations[7] based on information discovered during commissioning,
    - Functional test procedures and results,
    - Reports that document all commissioning field activities as they progress, and
    - A description and estimated schedule of required deferred testing.

APPENDIX

Endnotes:

[1] In this document, the term “building commissioning” refers to commissioning of complete buildings, building systems, and process systems located with the building.

[2] The BCxA recognizes that some projects may benefit from services and deliverables that do not include all of the Essential Attributes of Building Commissioning. While such scopes of work may add value to a project, the BCxA does not recognize them as complete commissioning processes. However, it is not the intent to restrict BCxA members from performing such services when they are clearly described as something other than full commissioning.

[3] The systems that must be commissioned for a functionally successful project may vary depending on the nature of the project; therefore, specific systems to be commissioned are not listed as essential attributes. However, as a means of maximizing indoor environmental quality and minimizing global environmental impact, the BCxA encourages total building commissioning, including mechanical, electrical, plumbing, automation and building enclosure systems.

[4] In this document, the term Project Documents refers to planning and programing documents, as well as construction documents such as drawings, specifications, submittals, operating procedures and other documents relevant to the construction and operation of the building systems.

[5] The term Commissioning Provider (CxP) is used within this document. Different terms, such as Commissioning Agent, Authority, Manager, etc., may be used in other documents and by other organizations.

[6] Often called functional tests, performance tests, or functional performance test procedures (FPTs), these tests are traditionally focused on confirming that systems function or perform in accordance with clearly defined acceptance criteria, while documenting sufficient data to clearly document a baseline of operation. For more complex or experimental systems, they may also be designed for fine tuning and to establish what the baseline of operation should be.

[7] By the 2nd decade of the 21st century, 2 decades after the Essential Attributes of Building Commissioning were originally adopted, it has become clear that many commissioning stakeholders find tremendous value in using commissioning to facilitate the efficacy of turning over new systems from the installing contractors to the building operating staff. As 2020 approaches it is becoming more common for owners to request services such as training by the CxP on information discovered during commissioning and confirming as a part of the commission process that critical operating resources and documentation are provided as a condition of project completion. While this might not be essential for the effective commissioning of all projects it is recommended as good practice for many projects.