

Best Practices in Commissioning Existing Buildings

Building Commissioning Association

Presented at the 16th National Conference on Building Commissioning by:

Mark Miller, PE, CCP, CEM, LEED™ AP

Principal, Strategic Building Solutions

Balaji Santhanakrishnan, CEM, LEED™ AP

Senior Energy Manager, Johnson Controls, Inc.

Synopsis:

The Building Commissioning Association (BCA) is committed to defining what the Best Practices are in the “Existing Building Commissioning” industry through the provision of a document that will detail practical solutions, facilitate the implementation of existing building commissioning Best Practices improvement over time, and assist in the standardization of the commissioning industry. The term “Best Practice” generally refers to the best possible way of doing something, taking the most successful elements from many different sources and combining them to create the optimal process or approach. This presentation will provide an over view of the Best Practices developed by the BCA, discuss the process involved in developing this document and the practical application of this process in current and future “Demonstration Projects”.

About the Authors:

Mark Miller, PE, CCP, CEM, LEED™ AP, Principal, Strategic Building Solutions, LLC has an extensive background in both energy management and building commissioning with large institutional and commercial buildings. He is founding President of the NE Chapter of the Building Commissioning Association (BCA) and Chair of the Retro-Commissioning Certification Sub-Committee for the national BCA.

Balaji Santhanakrishnan, Senior Energy Manager - Corporate Energy Services, Johnson Controls Inc. has over 14 years of international experience in the field of Energy Management & Commissioning and has worked on various Energy Management Programs both in Asia and in the United States. Balaji is a “Certified Energy Manager” and a recipient of the “AEE Energy Manager of the Year 2003 award”. He is currently serving as a national board of director of Building Commissioning Association and committee member of ASHRAE Commissioning Process for Existing HVAC&R Systems 1.2P.

Best Practices in Commissioning Existing Buildings Building Commissioning Association

Executive Summary

This Building Commissioning Association (BCA) defines Existing Building Commissioning as: *“...a systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low/no cost and capital intensive Facility Improvement Measures and ensuring their continued performance over time. The Existing Building Commissioning process assists in making the building systems perform interactively to meet the Current Facility Requirements. The term Existing Building Commissioning is intended to be a comprehensive term and process that encompasses the more narrowly focused process variations such as retro-commissioning, re-commissioning and ongoing commissioning that are commonly used in the industry.”*

The BCA is committed to defining what the Best Practices are in the “Existing Building Commissioning Industry” through the provision of a document that will detail practical solutions, facilitate the implementation of existing building commissioning Best Practices improvement over time and assist in the standardization of the commissioning industry. The term *best practice* generally refers to the best possible way of doing something, taking the most successful elements from many different sources and combining them to create the ultimate process or approach. This document looks in detail at these issues and helps understand and discuss why they are a Best Practice for continuous quality improvement across the commissioning industry. In order to meet our commitment to be the leading authority and clearinghouse for the commissioning industry, the BCA is implementing an evaluation strategy to ensure appropriate and effective evaluation of all commissioning standards and guidelines at all levels. Recognizing that each project might require a different approach depending on the circumstances, the BCA emphasizes that the list of Best Practices should not be understood as mandates. Subsequent to finalizing this document, the Public and members of the BCA Board and Chapters have been asked to comment and make suggestions. The “Best Practices”, therefore, will be presented by BCA as a document that presents a positive contribution to the Existing Building Commissioning Industry as a whole.

This document was created to define the qualities and characteristics of best commissioning practices and promote those practices in the market. Definition of Best Practices creates a benchmark against which the market can gauge quality and professionalism, and the BCA can use to objectively evaluate other commissioning initiatives, including our own. These Best Practices criteria will allow the BCA to compare/contrast commissioning processes, guidelines, training curriculum, certifications, etc. BCA best practices criteria were developed from sources such as the California Commissioning Collaborative guide for Existing Buildings, the Building Commissioning Hand Book by the Building Commissioning Association, NEBB National Environmental Balancing Bureau (NEBB) retro-commissioning process, Associated Air Balance Council Commissioning Group (ACG) Commissioning Guidelines, ASHRAE Guideline 0-2005, input from ASHRAE GPC 1.2, and SMACNA, among others. This report also draws extensively

PUBLIC REVIEW DRAFT

upon years of real world experience of the sub committee from managing a wide array of existing building commissioning projects.

The BCA is comprised of Principal Members who are owners, engineers, architects, contractors, providers and users of commissioning services in their day-to-day operations. The members represent a broad cross-section of interests and are associated with many sectors of the facilities and construction community.

The BCA Best Practices process is intended to communicate initiatives that are innovative, sound, and represent generally accepted standards. The processes and practices identified in this document are referred to as Best Practices. These Best Practices have been proven through experience and implementation and as a process would be beneficial for others involved in the Existing Building Commissioning process to use. Best Practices are a cornerstone of effective and efficient operation.

For best results the Existing Building Commissioning investigation process includes the owner's maintenance and operations staff, the owner's occupant representative(s) (building manager, school principal, department head, etc.), the building automation system maintenance contractor, and other contracted service personnel (if any), and the Commissioning Authority.

As the commissioning industry continues to mature and the professionals in this segment of the industry continue to gain experience and innovate, the list of Best Practices set forth here will very likely be refined and improved. These Best Practices are intended to promote quality, consistency, efficiency and flexibility in the existing building commissioning industry.

Accordingly, suggestions from other related industry and commissioning organizations are invited.

The Best Practices Task Force acknowledges the thoughtful and essential contributions made by the members of BCA in providing invaluable input and comment on the various drafts as we worked to complete this document since spring 2006.

1. Scope of Commissioning Activity	
1.1 Definition and Purpose of Existing Building Commissioning	
1.1.1	<p>Existing Building Commissioning is a systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low/no cost and capital intensive Facility Improvement Measures and ensuring their continued performance over time. The Existing Building Commissioning process assists in making the building systems perform interactively to meet the Current Facility Requirements. The term Existing Building Commissioning is intended to be a comprehensive term and process that encompasses the more narrowly focused process variations such as retro-commissioning, re-commissioning and ongoing commissioning that are commonly used in the industry.</p>
1.1.2	<p>The majority of existing buildings have not undergone any type of commissioning or quality assurance process. Additionally, over time the facility requirements change and the operational efficiencies of buildings tend to degrade. Because of these factors many buildings are performing well below their potential, use more energy than necessary and cost more to operate than they should. EBCx responds to an Owner’s desire to improve building performance, solve comfort and operational problems and reduce operating costs.</p> <p>The purpose of existing building commissioning is as follows:</p> <ul style="list-style-type: none"> • Verify that a facility and its systems meet the Current Facility Requirements • Improve building performance by saving energy and reducing operational costs • Identify and resolve building system operation, control and maintenance problems • Reduce or eliminate occupant complaints and increase tenant satisfaction • Improve indoor environmental comfort and quality and reduce associated liability • Document system operation • Identify the O&M staff training needs and provide such training • Minimize operational risk and increase asset value • Extend equipment life-cycle • Ensure the persistence of improvements over the building’s life • Assist in achieving LEED for Existing Buildings http://www.usgbc.org/LEED • Improve the building’s ENERGY STAR rating http://www.energystar.gov/
1.1.3	<p>Existing Building Commissioning promotes operations and maintenance and building performance excellence; but requires the involvement of all stakeholders including; senior management, engineering, operations and maintenance staff, facility users/occupants. The commissioning process is not a one time event, but rather an on-going activity that continues throughout the lifecycle of a facility.</p> <p>This document identifies distinct and sequential phases to the Retro-Commissioning process however it is important to recognize that the commissioning process is an iterative process that may repeat or loop back to previously completed phases over time. The basic phases and the goals of each phase of the Retro-Commissioning process are as follows:</p>

PUBLIC REVIEW DRAFT

	<ul style="list-style-type: none"> • <u>Planning Phase</u>: Development of the Retro-Commissioning goals, facility requirements, and a commissioning plan. • <u>Investigation Phase</u>: Field inspections, data gathering, testing and analysis to accurately assess system performance and identify improvement opportunities. • <u>Implementation Phase</u>: The desired facility improvements are completed and the results and performance are verified. • <u>Turnover Phase</u>: The systematic transition from a commissioning activity and the commissioning team to standard operating practice and the operations and maintenance team. • <u>Persistence Phase</u>: Implementation of systems and tools to support both the persistence of benefits and continuous performance improvement over time.
<h2>1.2 Commissioning Authority (CxA)</h2>	
1.2.1	The Commissioning Authority (CxA) is in charge of the commissioning process and makes recommendations to the owner regarding Facility Improvement Measures and assists in verifying their continued performance over time.
1.2.2	The CxA is an objective, independent advocate of the owner who leads, plans, and coordinates the commissioning team and commissioning process. Ideally, the CxA will be independent of the operations and maintenance team, without specific operational responsibilities, maintenance tasks or project responsibilities. The use of a 3 rd party “outsider” can be beneficial in that a fresh perspective is brought to the commissioning process that can challenge traditional O&M practices, infuse new enthusiasm, technical expertise and human resources into the process which will ultimately enhances the benefits achieved by the process. The CxA can be an independent consultant or a qualified employee of the Owner.
1.2.3	If the CxA is an independent consultant and the CxA’s firm is responsible for operational/maintenance duties, has other project responsibilities or is not under direct contract to the Owner, a conflict of interest may exist. Wherever this occurs, the CxA shall disclose, in writing, the nature of the conflict and the means by which the conflict shall be managed.
1.2.4	In addition to having good written and verbal communication skills, the CxA has current engineering knowledge and extensive recent hands-on field experience regarding: building systems commissioning, the physical principles of building systems performance, building systems start-up, balancing and adjusting, testing, troubleshooting, operations, maintenance procedures, building design and construction process.
<h2>1.3 Systems Included in Commissioning Process</h2>	
1.3.1	Existing Building Commissioning is a “whole-building” or “total building” process in which building systems and their interactions are tested and verified to suit current requirements. This integrated approach maximizes positive results and helps to ensure that the building is operated safely, efficiently, and meets the CFR. Although limiting the commissioning scope to focus on a single system (i.e. HVAC systems) or singular objective/goal (i.e. save energy) is a practice in the industry, this narrowing of scope is not

PUBLIC REVIEW DRAFT

	likely to produce a building that operates best overall.
1.3.2	<p>The following are several common building systems that should be included in the Existing Building Commissioning Plan (as applicable). However, this list is not all encompassing and each facility should be evaluated to determine what other specialized systems or system integrations should be included.</p> <ul style="list-style-type: none">• HVAC&R Systems• Building Assembly (Envelope, Interior, Paths of Egress, etc.)• Conveying Systems (Elevators and Escalators)• Protective Systems (Fire Suppression, Lighting Protection, etc.)• Plumbing Systems (Water Distribution, Sanitary/Storm Water, etc.)• Electrical Systems (Power Distribution, Lighting, etc.)• Communication Systems (Telecom, Sound, Video, etc.)• Alarm Systems (Fault Detection, Security, Leak Detection, etc.)

PUBLIC REVIEW DRAFT

2. Planning Phase	
<p>The objectives of the Planning Phase are to develop/confirm the Owner’s needs and requirements for the facility and document through the development of a Current Facility Requirements (CFR) document and to develop an Existing Building Commissioning Plan to define the commissioning process for the facility. If a 3rd party consultant will be utilized as the CxA for the project, the Contract with the consultant would be prepared and executed based upon the Owner’s CFR and the required scope of services.</p>	
2.1	<p>Define Roles and Responsibilities - The roles and responsibilities of all existing building commissioning participants and the Existing Building Commissioning Plan should be defined during this phase. Clear documentation of the Current Facility Requirements (CFR), which defines the Owner’s operational needs and requirements, should be completed prior to concluding this phase of the process.</p>
2.2	<p>Define Scope of Work, Schedule and CFRs - If a 3rd party consultant is utilized as the CxA, a clearly defined scope of work, schedule and Current Facility Requirements need to be understood, documented and agreed upon as part of the agreement and EBCx Provider’s contract. The roles of all the commissioning participants should be defined in the agreement. Based upon the size of the specific facility(s) and the scope of services the duration of the Cx contract may vary from just a few weeks to several years.</p>
2.3	<p>Define Existing Building Commissioning Goals – Clear goals and objectives for the commissioning process should be developed to focus the team and to provide guidance in the planning effort which culminates with the EBCx Plan.</p>
2.4	<p>Define Current Facility Requirements - The process should start with a review of, and if required, an update to the Current Facility Requirements (CFR) which defines the current operational needs and requirements of the building. For buildings that undertook the new building commissioning process the CFR is the evolution of the Owner’s Project Requirements (OPR) established during the original commissioning process. The EBCx Plan shall adequately address the Current Facility Requirements (CFR) in sufficient detail to allow for the documentation of and verification that those requirements are being met. If the building has had its usage changed from the original design, or if a current CFR does not exist, the Commissioning Provider and Owner should develop a detailed Current Facility Requirements (CFR). Items such as temperature, humidity, operating hours, filtration, sound, vibration, and/or specialty needs must be discussed and agreed upon in the CFR. The CFR should note any integrated requirements such as controls, Fire & Life Safety, Staff Training, Warranty review, Service Contract review, Security Systems, etc.</p>
2.5	<p>Preliminary Building Benchmarking - Perform preliminary building benchmarking of readily available data to quantitatively measure overall building performance. This preliminary benchmarking can help uncover potential opportunities and can be used as a baseline to measure future performance improvements during the commissioning process.</p>
2.6	<p>Review Existing Building Documentation - Review existing building documentation such as; building plans and specifications, Operations and Maintenance Manuals, maintenance documentation records, etc. This review helps to increase an understanding of the building, but the primary focus is to determine the availability of documentation for the EBCx Investigation process.</p>

PUBLIC REVIEW DRAFT

2.7	Interview Key O&M Staff Members - Interview key O&M staff members to learn from their extensive knowledge and experiences from working in the building on a daily basis.
2.8	Perform a Cursory Walk-Through - Perform a cursory walk-through of all major spaces to gain an understanding of the types of spaces, condition of spaces, occupancy levels, lighting and controls and prevalence of information technology related infrastructure and equipment.
2.9	Develop Existing Building Commissioning Plan - Develop a EBCx Plan that documents goals, roles, responsibilities, the EBCx process, communication protocols, major activities and tasks and the overall EBCx project schedule. It is important that the Plan give thoughtful consideration to the level of involvement of the Owner and how communication with key Owner constituencies will be handled to ensure consensus and success. The Plan is a working document that evolves throughout the commissioning process.
2.10	Develop a Customized Building Operation Plan - Develop a customized Building Operation Plan which identifies specific building, system/equipment level and zoning level operational strategies, set points and schedules which will support the operational needs and the CFR.

3. Investigation Phase	
<p>The objective of the Investigation Phase is to conduct the site investigation to compare the actual building conditions and system performance with the owner’s current operational needs and requirements defined by the CFR. This phase concludes with the completion and review of a Master List of Findings that identifies Facility Improvement Measures (FIMs) that upon implementation will improve building and system performance to meet the CFR, reduce energy and O&M costs and/or improve the indoor environmental quality.</p>	
3.0	<p>Commissioning Coordination – During the Investigation Phase (and throughout the entire commissioning process) the commissioning team should meet periodically to discuss Commissioning status, system performance, and issues identified. Owner participation in these status meetings is critical to solicit additional input, build consensus as well as to help address any simple repairs or adjustments that need to be made during this phase.</p>
3.1	<p>Documentation Review - Review building drawings and documentation to understand the building energy usage, initial basis of design and evaluate the system integration. The review process includes the evaluation of all old and new drawings, specifications, Test and Balance Reports, Operations & Maintenance Manuals (typically related to mechanical, electrical and controls), and any past Commissioning Reports.</p>
3.2	<p>Site Review/Survey - Conduct a thorough and detailed building walk through (maintenance staff participation is highly desirable) to evaluate the issues identified in the planning phase and observed during the drawing and documentation review. Important facility information not found during the Documentation Review may need to be recreated during the site survey (i.e. TAB analysis to determine current air/water flows, or if sequences of operation are unavailable, perform functional performance testing to determine how systems operate). During this step additional issues which are not captured through the documentation review should be noted.</p>
3.3	<p>Building Occupant Interviews – Interview the owner’s maintenance staff, utility staff, occupants, and other relevant parties to understand the current needs and issues related to system operations and maintenance. A formal interview process is recommended to systematically assist in understanding potential issues and problems, uncover potential improvement opportunities, confirm the CFR and to develop consensus on the commissioning process goals.</p>
3.4	<p>Facility Performance Analysis and Performance Baseline Establishment – Collect and analyze available energy, non-energy and other system performance data to establish baseline benchmarks for facility performance. Available facility performance baseline data may include utility billing data, sub-metering data, work orders, comfort complaint logs, indoor air quality parameters, occupant satisfaction survey results, building automation system trend data and/or stand alone data logger data.</p>
3.5	<p>Systems Diagnostic Monitoring – Develop a diagnostic monitoring plan and then perform comprehensive system diagnostic monitoring. Diagnostic monitoring methods can include; building automation system trending, portable data logger trending, and energy and weather data collection. The collected data is analyzed to identify issues and improvement opportunities and highlight particular problems that may require more rigorous and focused investigation. Analyzing the diagnostic monitoring data can also assist in determining if the</p>

PUBLIC REVIEW DRAFT

	system is meeting the CFR.
3.6	Test Development - Develop Test Procedures for the systems identified in the project scope. Test plans typically focus on confirming that the system performance is meeting the performance requirements of the owner set forth in the CFR.
3.7	System Testing - Perform system testing to evaluate the building systems performance. In addition, any anomalies or issues identified in earlier Investigation Phase steps should be considered for further evaluation during system testing to determine root causes and possible solutions. It is recommended that the testing process include the verification and calibration of critical sensors. Typically, critical sensors are those sensors which are essential to the effective and efficient operation of the building systems.
3.8	If appropriate and agreed upon by the commissioning team, perform simple repairs or improvements identified during the Investigation Phase monitoring and testing. The existing building commissioning process is intended to be an iterative and flexible process, therefore, some implementation may occur during the Investigation Phase and conversely further investigation may occur during the Implementation Phase.
3.9	Master List of Findings - Create a Master List of Findings that identifies possible Facility Improvement Measures (FIMs) based on the findings from the steps above. The following information on each FIM is desirable so that the owner has sufficient information to make an informed decision when selecting the FIMs for implementation; 1) Description of Finding, 2) The Solution/ Measure Description, 3) Benefits, 4) Drawbacks/Risks, 5) Implementation Cost, 6) Savings (details on the estimated electrical, fossil and demand energy savings may be desired), 7) Payback and Return on Investment (ROI) analysis and 8) Commissioning Team recommendation for implementation. Frequently, only rough budgetary implementation cost estimates are included in the Master List during the Investigation Phase with firm contractor quotes being obtained during the Implementation Phase once specific measures have been selected for implementation. The rigor of the energy saving calculation methodology utilized to estimate energy savings can vary significantly. Factors that impact calculation methodology rigor may include; utility program requirements if applicable, owner expectations, the level of investment required for measure implementation.
3.10	Performance Assurance - Evaluate methods of measuring system performance and verifying proper implementation to demonstrate the success of the FIMs implemented. Each measure should have a verification methodology appropriate to the size and complexity of the measure. The identified verification methodology is then incorporated into a Measurement and Verification (M&V) Plan. The M&V plan is intended to provide a comprehensive protocol to verify the performance of the measure/system and confirm that the predicted energy savings have been achieved upon the completion of implementation. Ongoing Building Automation System trending, portable data loggers, spot measurements, and functional testing may be utilized pre and/or post implementation as part of the M&V process.

4. Implementation Phase	
The intent of the Implementation Phase is to implement the Facility Improvement Measures (FIMs) that are selected from the Master List of Findings and to verify that the predicted results are achieved.	
4.1	Analyse, Prioritize and Select Facility Improvement Measures - The Implementation Phase begins with the analysis, prioritization and selection of FIMs for implementation. The Owner, with any necessary support from the Commissioning Team, evaluates and prioritizes the measures that have been recommended for implementation by the Commissioning Team. The final selection of measures for implementation and implementation timing is frequently influenced by many factors including; ROI and simple payback, budgetary constraints, anticipated facility impacts, future capital plans, available implementation resources, etc.
4.2	Prepare an Implementation Plan - Upon measure selection the commissioning team prepares an Implementation Plan to guide the implementation process and provide details on steps to be followed to complete the implementation of the selected Facility Improvement Measures. This plan typically indicates which improvements will be made during the Implementation Phase and which ones will be deferred with a timetable for planned implementation as capital improvement projects, with the ultimate goal of having the systems perform efficiently to meet the CFR.
4.3	Implement Selected FIMs – As defined by the Implementation Plan, the selected improvements to the systems and operations are undertaken and completed.
4.4	Verify Successful FIM Implementation – Testing or re-testing is performed on modified or upgraded systems to demonstrate that the improvements are successful. Plans are also made for the future testing of the deferred capital improvement projects identified. If testing does not show that the improvements were successful, further modifications or refinements to the upgrades should be made to achieve acceptable results.
4.5	Execute the Measurement and Verification (M&V) plan – Implement the M&V Plan developed during the Investigation Phase to evaluate project success and final energy savings as a result of the project.
4.6	Plan for Ongoing Commissioning – Plans are made to continue elements of the commissioning verification process on an ongoing basis to help the improvements to persist over time. Certain steps may be repeated at regular intervals to facilitate this.

5. Turnover Phase											
<p>The intent of the Turnover Phase is to ensure a smooth transition between the commissioning team and the personnel responsible for operating and maintaining the building over its lifecycle (the O&M personnel). Successful transitions ensure that all necessary documentation, knowledge and systems are provided to the O&M personnel and that the O&M personnel demonstrate the effective use of these tools so that the Current Facility Requirements are met and the positive results persist far into the future.</p>											
5.1	<p>Update O&M Manuals and As- Built Documentation - Update O&M manuals and as- built documentation as required. If the Owner has acceptable, up to date O&M manuals, then O&M manuals only need to be modified to include any changes to equipment or operations that were made as part of the existing building commissioning project. If existing manuals are not adequate to support effective O&M of the existing equipment, the Owner should consider including a task in the existing building commissioning scope to improve them.</p>										
5.2	<p>Develop Final Report & Update Documentation. - The final report is a record of the existing building commissioning activities and measures that were implemented for the Owner and will become an important document for the building and an invaluable resource to current and future building operators.</p>										
5.3	<p>Compile or Update a Systems Manual - Compile or update a Systems Manual as required by CFR. A systems manual is a compilation of important building documentation such as the CFR, systems description, a narrative descriptions of the Sequence of Operation and the Final report. The system manual will greatly enhance the building staff’s ability to operate the building effectively.</p> <p>The systems manual should include the following information:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">- Index</td> <td style="width: 50%;">- CFR</td> </tr> <tr> <td>- Construction record documents, specifications, submittals</td> <td>- Basis of design</td> </tr> <tr> <td>- A list of recommended operational record keeping procedures</td> <td>- O & M manuals</td> </tr> <tr> <td>- Ongoing optimization guidance</td> <td>- Training materials</td> </tr> <tr> <td>- EBCx report</td> <td></td> </tr> </table>	- Index	- CFR	- Construction record documents, specifications, submittals	- Basis of design	- A list of recommended operational record keeping procedures	- O & M manuals	- Ongoing optimization guidance	- Training materials	- EBCx report	
- Index	- CFR										
- Construction record documents, specifications, submittals	- Basis of design										
- A list of recommended operational record keeping procedures	- O & M manuals										
- Ongoing optimization guidance	- Training materials										
- EBCx report											
5.4	<p>Establish a Plan for Operational Sustainability, Ongoing Commissioning and Continuous Improvement. - A plan for operational sustainability and ongoing commissioning is developed during this process to ensure the persistence of results and continuous improvement and is a key deliverable of the Turnover Phase. The plan will provide the building staff with detailed instructions, systems and tools for strategic operational, monitoring and maintenance tasks that help maintain the commissioning process performance benefits and support continuous improvement. The plan may include recommendations and instructions related to; establishment and monitoring of energy and non-energy facility performance benchmarks, energy tracking, preventive and/or predictive maintenance, building automation system trending, training, and procedures for updating CFR and other documentation.</p>										
5.5	<p>Develop Training Plan - Develop Training Plan, provide training and plan for future training. The Owner’s building operating staff should be part of the commissioning team and be involved in all phases of the existing building commissioning process to understand the findings, changes and improvements stemming from the commissioning process. Training should be pervasive throughout the commissioning process. The Turnover Phase provides</p>										

PUBLIC REVIEW DRAFT

	an excellent opportunity to provide focused training on the existing building commissioning process, the associated FIMs implemented, system optimization techniques and strategies for persistence and continuous improvement. Establish a Training Plan for future training based upon the current staff training needs, estimated future needs (including “re-fresher” training), and training for continuous improvement of staff skills.
5.6	Hold a Lessons Learned Meeting - Hold a Lessons Learned Meeting with the Owner’s building operating staff and other commissioning team members. This can help the operating staff in maintaining the performance benefits for existing building commissioning and can increase their knowledge expanding their ability to identify and address improvement measures in the buildings in which they work.

6. Persistence Phase	
<p>The intent of the Persistence Phase is to ensure that all the Facility Improvement Measures continue to perform properly over their life cycle and that systems and tools are provided and employed to facilitate the continuous improvement of facility performance to meet the Current Facility Requirements.</p>	
6.1	<p>Implement the Plan for Operational Sustainability and Ongoing Commissioning - Implement the plan for operational sustainability and ongoing commissioning developed as a result of the commissioning process to support the goal of continuously improving facility performance.</p>
6.2	<p>Benchmark the Building Energy Use - Continue to benchmark the building energy use to compare to other similar buildings and to the original building prior to implementing the EBCx process. This is a way for owners to assess how their building is performing compared to peer buildings. Establish annual benchmark score improvement goals and consider recognition/rewards for goal achievement to encourage continuous improvement efforts. ENERGY STAR Portfolio Manager is a frequently used and nationally recognized building energy benchmarking tool among others. https://www.energystar.gov/istar/pmpam/</p>
6.3	<p>Monitor and Track Energy Use - Track energy use to monitor changes on an ongoing basis. Utility tracking records a building’s energy use over time and helps the operating staff understand the building’s consumption patterns. Track energy consumption and cost regularly by analyzing utility bills and consider implementing a “real time” energy tracking system. Increasingly “real time” energy tracking tools i.e. “Energy Dashboards” are being employed so that the operating staff can observe on a “real time” basis key energy parameters and continuously compare to previous day, previous month and previous year figures. Establish specific energy type (i.e. electricity, natural gas, etc.) and system level performance targets to help drive energy performance.</p>
6.4	<p>Monitor and Track Non-Energy Building Performance Metrics - Monitor and track non-energy building performance metrics such as comfort calls, occupant satisfaction, indoor air quality parameters, etc. to assess building performance and compare to benchmarks established prior to and during the commissioning process.</p>
6.5	<p>Trend Key System Parameters - Trend key system parameters to detect problems early and assess system performance. Trend logging through the building automation system is important for observing the performance of systems under various modes and operating conditions over time. Trending is also an important tool to ensure that the implemented facility improvement measures continue to perform properly.</p>
6.6	<p>Document Changes with an Operator’s Log - Utilize an operator’s log to keep a record of significant events such as equipment replacement, maintenance or testing, and problems and their resolution. If possible, the log should be kept electronically to allow for easy searching. CMMS (Computerized Maintenance Management System) software is commercially available to aid in this documentation and can be used as an asset maintenance scheduling and record system.</p>
6.6	<p>Implement Persistence Strategies with The Building Automation System - Utilize the existing Building Automation System software and graphical user interface to facilitate operator awareness and persistence of FIMs. Set up triggers to check for any variance</p>

PUBLIC REVIEW DRAFT

	within the FIMs. Ensure that any variance from the original intent of the FIMs are immediately recorded and incorporated into the O&M and work order generation procedures of the facility.
6.7	Consider Automated Commissioning and Continuous Diagnostic Tools - Consider automated commissioning and continuous diagnostic tools that are integrated with the building automation system to automatically detect faults and alert operators when faults are identified in sensors, valves, dampers and energy efficiency sequences.
6.8	Implement Staff Training Plan - Implement staff Training Plan and update Training Plan as required.
6.9	Implement the Commissioning Process Again (Re-Commission) - Implement the commissioning process again (Re-Commission) on a periodic basis. Conduct the re-commissioning either on a regular schedule (a 3 to 5 years is a frequently cited time frame), or if building performance degrades, or if the building occupancy or usage changes significantly.

ACKNOWLEDGEMENTS AND RESOURCES

1. "ACG Commissioning Guideline" by the Associated Air Balance Council Commissioning Group (ACG)
2. ASHRAE Guideline 0-2005 "The Commissioning Process" by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
3. The Building Commissioning Hand Book by the Building Commissioning Association
4. "California Commissioning Guide: Existing Buildings" by the California Commissioning Collaborative (CA Cx)
5. "LEED-EB for Existing Buildings" Version 2.0 and "LEED for Existing Buildings: Operations & Maintenance" by the United States Green Building Council
6. NEBB National Environmental Balancing Bureau (NEBB) guide
7. SMACNA- Sheet Metal and Air Conditioning Contractors National Association, Inc.
8. "Strategies for Improving Persistence of Commissioning Benefits" by Hannah Friedman, Amanda Potter, and Tudi Haasl of Portland Energy Conservation, Inc. David Claridge, Texas A&M Energy Systems Laboratory

Existing Building Commissioning Definitions

1. Automated Commissioning and Continuous Diagnostic Tool:

Automated Commissioning and Continuous Diagnostic Tools are programs that are integrated with the building automation system to automatically detect faults or abnormalities in operation of systems and alert operators when they occur in sensors, valves, dampers and energy efficiency sequences.

2. Benchmarking:

Benchmarking is the process of comparing a building's energy usage to other similar buildings and to the building itself prior to the retro-commissioning process. Developing standards and goals for energy management is a good way to motivate people to improve towards the goal of optimal energy performance. ENERGY STAR Portfolio Manager is a frequently used and nationally recognized building energy benchmarking tool, among others.

3. Building Operation Plan:

A Building Operation Plan identifies specific building, system/equipment level and zoning level operational strategic set points and schedules which will support operational needs and the Current Facility Requirements (CFR). [Check out CCC's BOP and what LEED says BOP should be, if someone has an application manual]

4. Computerized Maintenance Management System (CMMS):

An electronic version of an operator's log which keeps a record of significant events such as equipment replacement, maintenance, testing and problems along with their resolutions. Commercially available CMMS software is easily searchable and can be used as an asset maintenance scheduling and record system. [Maybe say something about what input is required to set up CMMS]

5. Current Facility Requirements (CFR):

Defines the Owner's current operational needs and requirements for a building. It typically includes items addressing temperature and humidity set points, operating hours, filtration, vibration, sound and/or specialty needs. The CFR should note any integrated requirements such as controls, fire and life safety, warranty review, service contract review and security systems. [Also gives history of building, functional use(s), etc. Again, may want to reference CCC BOP/CFR for stuff to include in CFR.]

6. Energy Dashboard:

Energy Dashboards are “real time” systems that track a building’s energy usage and/or key system performance characteristics. After energy saving targets have been established for a building, energy dashboards expedite the process of monitoring ongoing performance against the previous day, month or year’s figures.

7. Facility Improvement Measures (FIMs):

Alterations or revisions to systems or equipment planned to improve building and system performance, reduce Operations and Maintenance (O&M) costs and/or improved the indoor environmental quality as part of an Existing Building Commissioning Effort.

8. Implementation Plan:

A written document that details the prioritization and selection of FIMS for completion during the Implementation Phase.

9. Lessons Learned Meeting:

A meeting held during the Turnover Phase to discuss what went right and what went wrong during the Existing Building Commissioning process. Attendees include the Owner’s building operating staff and members of the commissioning team.

10. Master List of Findings:

The Master List of Findings is a document assembled at the end of the investigation phase of a retro-commissioning project. It serves as a preliminary budgeting tool and identifies possible Facility Improvement Measures (FIMS) to be included in the implementation phase to follow.

11. Measurement and Verification (M&V) Plan:

Measurement and Verification (M&V) Plan uses ongoing building automation system trending, portable data loggers, spot measurements, and functional testing to measure the efficacy of each FIM and verify its proper implementation. It is intended to verify the performance of the measure/system and confirm that the predicted energy savings have been achieved upon the completion of implementation.

12. Ongoing Commissioning:

The application of commissioning related process activities on an ongoing or continuous basis to ensure that the Current Facility Requirements are being met and to support the

continuous improvement of system performance. The Ongoing Commissioning Plan details how these activities and goals will be achieved.

13. Operations and Maintenance Manual:

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

14. Owner's Project Requirements (OPR):¹

A written document that details the functional 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. (The term *Project Intent* is used by some owners for their Commissioning Process Owner's Project Requirements.)

15. Re-Commissioning:

The periodic re-implementation of the commissioning process, either on a regularly occurring schedule (every 3 to 5 years is typical), or if building performance degrades, or if the building occupancy or usage changes significantly.

16. Retro-Commissioning:

The application of the commissioning process to an existing building that has not previously undergone the commissioning process.

17. Return on Investment (ROI):

The ratio of the money gained or lost on an investment relative to the cost of the investment. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio.

$$\text{ROI} = (\text{Gain from Investment} - \text{Cost of Investment}) / \text{Cost of Investment}$$

18. Systems Manual:¹

A system-focused composite document that includes the operation manual, maintenance manual, and additional information of use to the Owner during the Occupancy and Operations Phase.

19. Test Procedure:¹

A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

20. Training Plan:¹

A written document that details the expectations, schedule, budget, and deliverables of Commissioning Process activities related to training of project operating and maintenance personnel, users, and occupants.

21. Turnover Phase

The phase of Retro-Commissioning where all necessary documentation and training are provided to the O&M personnel to ensure that they understand how to use the commissioning tools and make sure that positive results persist far into the future.

1. Definition from ASHRAE Guideline 0-2005, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 1791 Tullie Circle NE, Atlanta, GA 30329