

Full Service Owner - Developing and Keeping In-house Commissioning Expertise

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Synopsis

Sandia National Laboratories is a full service owner, beginning with planning and project management and finishing with construction inspection and acceptance, as well as building operations and maintenance. Sandia has a very detailed project process, with many 'silos of excellence' contributing to eventual project success. The goal is to integrate commissioning into the project process to improve the end product and achieve a more effective transition from design and construction to building management, efficient operations and customer satisfaction.

The objectives of the paper and presentation are to briefly share Sandia's experience with commissioning (central plants, cleanrooms, lab/offices and design/build office buildings), the lessons learned and the current effort and challenges to develop a formalized commissioning program and to develop and keep an in-house commissioning team, leveraged by partnering with commissioning service providers and construction contractors. The primary thesis of this paper is that developing, communicating, and carrying out the roles and responsibilities of the commissioning team are key to the long term success of the program.

About the author

Ralph Wrons, PE, has been a facilities engineer at Sandia National Laboratories in Albuquerque, NM for 15 years. His work experience includes 3 years as the team leader for the Facilities Control System (FCS), 7 years as the Energy Manager, and the last 2+ years as a team leader in the Construction Inspection and Acceptance Department. He has a B.S. in Energy Engineering (1986) from the University of Arizona.

Ralph has been a proponent of building systems commissioning since his FCS days, taking the inaugural commissioning seminar from ASHRAE in 1995, and currently serves on the Facilities team to develop a formal commissioning program. Past challenges include selling and implementing the concept of Thermal Energy Storage, for which Sandia received a 2001 Federal Energy Management Program achievement award, and promoting and implementing a Sustainable Design program, for which Sandia has received several recognition awards, including the 2002 Department of Energy Sowing the Seed program award and a 2000 State of New Mexico Green Zia Environmental Excellence program award.

Introduction

Sandia is a government-owned, contractor-operated national laboratory, operated for the Department of Energy by Lockheed-Martin, with locations in Albuquerque, NM and Livermore, CA. The focus of this paper is only on the Albuquerque site, where the Facilities Management and Operations Center (FMOC) has a management-supported effort to develop a formalized commissioning program.

Since 1998, numerous Facilities staff have taken the 2-day and 5-day commissioning courses that are offered by ASHRAE, UW-Madison and the Building Commissioning Association. Many of those trained staff are serving on a committee to develop a formalized commissioning program in the midst of the largest building boom of Sandia's 55-year existence. The boom includes several complex laboratory facilities. Employing rigorous building systems commissioning is essential to assuring that project requirements are met at "ribbon cutting", not months later, which can result in dissatisfied customers and damage to FMOC reputation. Project requirements include the capacity, functionality, and efficiencies of systems, delivered on time and on budget, and green building certification in some instances.

Full-service owner = good candidate for in-house commissioning

The Sandia Facilities Management and Operations Center is a full-service landlord from project conception to demolition, with everything in between. The FMOC includes departments for Project Planning and Development, Project and Construction Management, Systems Engineering, Building Management, Construction Inspection and Acceptance, and Operations and Maintenance. Within those structures are numerous specialties, such as the Facilities Control System (FCS-HVAC controls), Life Safety systems engineering and maintenance, Vibration analysis, Service Contracts administration, etc.

While there are various means to initiate and fund projects, they all have to pass through a typical process of planning, design and construction, with a project manager (PM) assigned to take the project to completion. Depending upon the source of funding, the process can be quite deliberate. And although the process is deliberate, it typically does not include commissioning and the PM's involvement diminishes quickly when the construction phase is done.

The Project Management team includes the Sandia team – the PM, the assigned architect and systems engineers (civil, structural, mechanical, and electrical), the PM administrative assistant – and the A/E firm. The PM also solicits design QA review from several supporting entities, such as fire protection engineering, FCS, O&M, and construction inspectors. The construction inspection team is typically assigned after design is complete, but some projects assign earlier to solicit their review of the design. The PM typically serves as the Construction Manager (CM), though of late several staff

augmentation positions have been created for the express purpose of construction management.

Every project relies significantly on Sandia's standard construction specifications (<http://www.sandia.gov/engstds/specifications.html>). Many of the specs have testing and acceptance language, and contractor adherence to the specs goes a long way to meeting commissioning requirements. Among other duties, the construction inspection team (A/C/S/M/E disciplines) is charged with assuring that the drawings and specs are followed.

Sandia directly contracts the test & balance (T&B) firm as another QA/QC measure. The T&B firm typically works in concert with the FCS personnel who have the responsibility for the controls programming and database. These three entities working directly for the owner are just one example of Sandia's process that precedes a formal Cx program, and likely more effective once one is in place.

Not quite commissioning

Sandia FMOC has had the capability all along, (i.e., the roles & responsibilities) we just have not been able to focus the effort. Many personnel have had an understood, yet undefined, commissioning role for many years, (e.g., the FCS personnel) the construction inspectors, the systems engineers and the O&M team. Prior to commissioning per se and even now during its partial implementation, Sandia has overall been successful in the delivery of projects into functional, maintainable facilities for the customer's use.

These groups 'rise to the occasion' whenever it is necessary to overcome design and construction problems in the turnover of new facilities for beneficial occupancy; they are examples of the many 'silos of excellence' mentioned earlier. In part, their success in problem-solving 'in a pinch' has been a barrier, in that it has stymied a management consensus that FMOC needs to invest in the personnel resources and up-front expense of commissioning.

The ad hoc-commissioning of projects has not been procedures-based, is not well documented, and has not routinely resulted in successful turnover at actual project completion. The challenge is to integrate the various 'silos of excellence' for a coordinated, maximized, and documented team effort in the commissioning of new and renovated facilities/systems.

What does Sandia FMOC expect from commissioning that is not presently, routinely being delivered in construction projects?

- 1) Find errors and omissions in design before they are installed in construction.
Included in this is improved maintainability of systems.
- 2) Regular, knowledgeable and consistent adherence (complemented by enforcement) of design criteria and construction specifications.
- 3) Determine acceptance criteria ahead of time, and assure full and/or intended functionality of systems at turnover ("ribbon-cutting").

- 4) Achieve a more effective transition from construction to building management, efficient operations and customer satisfaction.
- 5) Document the design basis and the baseline performance of systems, by project completion and during warranty phase. Develop systems manuals for the building operators and systems engineers.

Getting Started with the Process

We first raised the visibility of commissioning to management with the PETL (Processing and Environmental Technologies Laboratory) project, which was designed in 1996-1997 and constructed in 1998-2000. The construction documents included a commissioning specification, which was customized from the ASHRAE course-provided template. While there was not per se design-phase commissioning, Sandia's project process allows considerable opportunity for design review and the mechanical project engineer did a good job of incorporating review comments that improved efficiency, functionality, cost-effective maintenance, and flexibility. Still, the PETL effort came up short in delivering on the promise of commissioning, as there were many errors after construction was complete that had to be corrected and that didn't sit well with those who inherited the engineering support, and operations and maintenance of the building.

Prior to and coinciding with that project, several project team members took either the ASHRAE or University of Wisconsin course on commissioning. Since then, several major projects have followed, with a combination of 3rd party commissioning expertise and in-house commissioning resources [See **Table 1.**]

Going from Ad Hoc to Formalized

The level 2 manager of sites management (the system engineering departments and the building management department) is a proponent of commissioning. His background is strong in maintenance planning and funding for reducing maintenance back-log. He recognizes the need to turn over a project from design and construction that is fully functional and cost-effectively operational and maintainable. In stressing that he wanted the systems engineers more involved and more accountable for that goal, he dedicated funding in FY03-04 for the development of a formalized commissioning program.

Most of the funding has paid for selecting and funding two contract commissioning service providers for their expertise in the commissioning process, and commissioning practice and results, and a single FMOC staff engineer to shepherd the process. Much progress has been made, but there have been FMOC personnel changes along the way that have resulted in delays for finishing and implementing the formalized program. One design/build office building project was selected as a pilot project for in-house commissioning team effort in FY04. The expectation is that once the program is finalized, each project will budget for and accomplish commissioning, appropriate to the scope of the project.

At any given time (of late), Sandia Facilities is running 45-60 fixed price projects of varying size, scope, and complexity, with perhaps double that number in time and

material (T&M) projects of lesser size and complexity. The costs are on the order of \$90-120 million per year. With the exception of the mid- to large-scale projects named below, all of these projects are not receiving a procedures-based level of commissioning. The irony is that there is no better time to begin commissioning projects with an in-house team than now,. However, in this instance, the program, the resources and the advance planning were not in place. The list below indicates that several structures of commissioning have been and are being employed during this boom.

Table 1. Sandia projects commissioned or underway

PROJECT	DESCRIPTION	COMMISSIONING APPROACH	STATUS
Processing and Environmental Technologies Laboratory (PETL)	151,000 SF materials sciences lab/office building. First Sandia project to include a commissioning specification.	PETL project mechanical engineer served as in-house CxA; GC hired a Test engineer (TE), per the spec.	Occupied 4 years. Multiple follow-up investigations & fixes required
Model Validation Systems Certification & Testing Lab	18,000 SF control center/office building. Design/Build project.	Used customized BPA template spec. PM elected to have D/B contractor supply the CxA. Commissioning was haphazard.	Occupied 2.5 years. Multiple follow-up investigations & fixes required
Joint Computational Engineering Laboratory (JCEL)	64,000 SF computing prototype lab/office building, including ChW/HW plant.	First project to employ both owner's CxA and GC's TE.	Occupied 1 year. Contractor call-backs reduced.
Central Plant upgrade – add Medium Temperature VSD chiller and variable volume pumping	2600-ton chilled water plant, with chilled water TES, for research chip fab facility and 9 other buildings. System kept operational during upgrade.	A/E firm supplied separate Cx specialist; wrote FTPs, implemented by Sandia SE & FCS	Completed 1 year ago. Full functionality achieved at outset.
Microsystems Engineering and Science Applications Laboratory complex (MESA)	377,000 SF multi-building complex. Utilized PETL Cx lessons learned as starting point. Division 1, 15 & 16 Cx specs.	CxA and TE both work for owner, after negotiating out the need for GC to hire TE. GC using an MEP coordinator.	Construction in progress, nearly complete. Cx lagging behind construction
Center for Integrated Nano Technologies (CINT)	95,000 SF Nano Science lab/office building.	First to utilize design-phase commissioning. TE/CxA working for GC	Construction in progress.
Building 971 general purpose office building	18,600 SF office building; Design/build, using the Institutional General Plant Project (IGPP) funding source.	Piloting the in-house Cx team approach	Occupied 8 months. Minor problems, corrected early.

Lessons learned

A facilitated ‘lessons-learned’ meeting was held a few months after the completion of the PETL commissioning effort, for the primary purpose of input to commissioning criteria and specifications by the MESA project team (see Table 1).

The following is a list of the primary findings:

- Make sure roles and responsibilities are well defined, during design phase.
- Make sure we actually do a separate “Design Intent” document.
- Tie the payment of \$ to the GC to commissioning milestones
- Make a chart in the specs for when everything is due to clarify schedule and deliverables
- Do not assume that if it is in black & white in the specs that you’re covered.

Enforcing the terms of the contract is essential, both for design and construction, but not easy. Even with contractual specifications, Sandia has had to ‘lead contractors by the hand’ to implement the commissioning requirements (including it in the master schedule, installation verification, pre-functional checks, detailed start-up plan).

“Commissioning is only as good as the enforcement of the spec”, said one of the inspectors involved in the MESA construction project, who was also involved in the PETL construction project.

Short lessons learned about a year after completion of the JCEL project:

- The buy-in of the GC is essential. Like safety, if the GC doesn’t believe in it, neither will the sub-contractors.
- Contractors, and even some Sandia staff, have not taken seriously the requirement for commissioning. There has been a steep learning curve.
- The less standard requirements to the GC and subs at the outset must be highlighted and emphasized as necessary.
- Invoice approvals should be tied to meeting Cx milestones
- The TE was policing the programming, done by the in-house controls group. “The burden of proof is on us sooner.”

It turns out that after many more project commissioning efforts, the lessons learned from the PETL project still apply.

Another consideration is that the 3rd party commissioning service provider is an advisor to the owner, and as such does not have the authority to enforce the drawings and specifications. This points to the need to identify the clear line of authority that communicates commissioning findings, and the need for that primary project team member to be the champion for commissioning, from project to project.

Roles and Responsibilities

The attached matrix was developed during the course of the pilot effort for in-house commissioning of the office building design/build project. While acknowledging the importance of starting earnestly in pre-design and design, the matrix addresses only the construction-phase.

Sandia FMOC and other Sandia organizations have “user” experts who accept many of the systems or equipment before the contract can be called complete. One viewpoint is these experts help achieve the intended and required purpose of the facility. Another viewpoint is these experts are an imposition on the GC and that numerous cost, schedule and performance milestones have been negatively impacted over the years. As mentioned earlier, the key is to coordinate and maximize their involvement, to achieve a successful commissioning effort.

Acronyms used in the matrix that may be unique to Sandia:

- SE = Systems Engineer. The Systems engineers include all disciplines and have the ultimate responsibility for the design basis and the life cycle operations and maintenance of the buildings and infrastructure. The systems engineering group is responsible for the construction specifications and for developing the formalized commissioning program. Some of the responsibilities include: fire protection systems, water treatment panel, chemicals and acceptance, electric meter and programming, lightning protection systems.
- SDR/ITL = Sandia delegated representative, on behalf of the construction procurement agent, to review, inspect and accept the work in accordance with the applicable codes, specifications and drawings. The SDR also serves as the Inspection Team Leader.
- SCO = Sandia Construction Observer, or commonly referred to as Inspector. Each project is typically assigned an A/C/S inspector, a mechanical inspector, and an electrical inspector. Sandia adopted the International Building Code in 1998 and each inspector is International Code Council-certified. The inspectors are the field representatives of the SDR and increasingly are tasked with using the Standard Specs compliance checklists that were developed in 2002.
- FCS provides controls commissioning performance design criteria on Direct Digital Control systems. During construction, the FCS personnel provide the controls cabinet (processor and I/O modules), controls programming and graphics, checkout of code, and performs controls system functional performance tests. Also provides start-up and commissioning of variable frequency controllers.
- BMT = building management team and its interface with the operations and maintenance group. The O&M group provides fire alarm acceptance, power transformer & acceptance, lighting inverter & acceptance, pump base grouting and laser alignment.
- Groups external to, but interfacing with Facilities: Communications, Intrusion Alarms, Access Control

In the last three years, Sandia FMOC, on another initiative aimed at streamlining the process for design firm contracting and construction firm contracting for projects less than five million dollars, short-listed several firms in each category after an RFQ process and entered into “partner” contracts. These design partners and construction partners

have an important role and important responsibilities in meeting the commissioning quality goal.

Program

The Sandia team is nearing completion of a standard commissioning specification (01810), and updating other division 1 specifications, to specifically address schedule, O&M manuals, project quality and contract closeout. To address one of the lessons learned, there is a statement in the 1810 Spec summary that makes it known that approval of progress payments will be tied to meeting commissioning milestones in the schedule.

Coincident in development are three new special specifications (13995, 15995 & 16995) which will be templates to be customized for each project. There are also placeholders for commissioning support specifications in division 2, 7 & 8. Once the specs are approved, the plan is they will be utilized for every commissionable project.

Also in the charge is to determine the graded approach in applying commissioning to the various projects which occur, for cost-effectiveness. The Systems Engineering department manager has stated, “all projects will be commissioned”.

The 4-tier graded approach to commissioning, as far as assigning a CxA:

- 1) contract commissioning service provider for large projects, e.g., MESA, CINT
- 2) A/E firm for mid-range projects
- 3) In-house team for small D/B and design-bid-build, e.g., IGPP
- 4) Inspectors for small replacement projects

In draft stage is a rewrite of the General section (Chapter 2) of the Design Manual, which will describe the design and construction process Sandia intends to follow, emphasizing the context and process of Total Building Systems Commissioning.

Another group, in a separate effort, is developing a flow chart of the project process from conception/planning to turnover. Members of the commissioning team have given input, to show the steps for commissioning development, beginning with budgeting for commissioning and finishing with the final commissioning report, training and turnover.

Conclusion

Several steps need to happen in order to develop the dedicated, coordinated in-house commissioning team. The paper exercise (specs and Design manual guidance and process diagram) is nearly complete. The people exercise is the vital next step.

Leadership and commitment is essential, from FMOC upper management, from the Project Managers, and from the designated Commissioning Authority(s), which will be dependent upon the type of project. Adding a commissioning spec to the long list of project specs and hiring a CxA is not the panacea. “Writing a better spec is not necessarily going to make it happen. It’s going to take leadership,” said the FMOC level

II manager for Project Management (including Project Controls and Construction Acceptance).

This brings the program to the important step of establishing roles and responsibilities. The new 1810 Commissioning Spec includes some mention, for the benefit of the construction contractor. Now it must be done for the benefit of FMOC and the implementation of the emerging commissioning program. Short of developing a Projects Commissioning department, having these roles and responsibilities defined and communicated and integrated into the process will be the only way to effectively deliver on the promise of commissioning.

We will likely need to rewrite the agreements between Sandia and its design partners and construction partners to better define the expectations of delivering commissioned projects. Next we should hold “lunch and learn” sessions to communicate these goals and requirements and perhaps even hold joint sessions to emphasize the need for a team approach. During this session, it could also help to convince the contractor that their involvement in a rigorous commissioning process can actually increase their profit, e.g., finish on time and reduce contractor call-backs, and improve their reputation.

Another challenge is to try to determine the savings of design-phase and construction-phase commissioning. The dollar benefits of Cx are difficult to quantify because it is largely mistakes found and corrected by procedures-based commissioning that must be accounted for and that takes more time and expertise to assign \$ to avoided mistakes. However, doing so will likely help to convince some of the remaining skeptics.

Sandia has a vested interest in developing and keeping the commissioning expertise in-house, rather than relying on 3rd party commissioning service providers. The team will have the authority to enforce the contract documents. The team is more likely to find and fix the problems, and improve their diagnostic abilities along the way. The team will be able to feedback improvements to the planning, design and construction process. The challenge is to convince the leadership to dedicate the resources.

SNL In-House Commissioning (construction phase) – Matrix of Responsibilities

	GC&SUBS	PM and/or CM	SE's and/or CxA	SDR/ITL & SCO's	A/E firm	FCS or Fire Protection	T&B (and/or other contract test firms)	BMT (BM or Maintenance)
DRAWINGS, SPECIFICATIONS, UCP (Universal Construction Package)		PM distributes to SE's, SCO's & SDR. Provides drawings only to FCS & T&B contractor (opens release)	QA review and feedback to A/E firm. Review UCP to ensure appropriate specs are checked; FCS & T&B boxes are checked	QA & constructability review and feedback to A/E firm via PM	P.E.'s stamping drawings perform rigorous QC at 60% & 100% design.		Review HVAC drawings, provides QA comments & T&B estimate to PM	
DESIGN INTENT DOCUMENT (DID)			Review to ensure it meets need		Finalizes DI document			
PRE-BID & PRE-CON		PM draws attention to Commissioning during both preliminary meetings with Contractor						
SPECIAL SPEC REVIEW	Review with SDR/SCO's & CxA		CxA reviews at outset of construction, prior to submittals	Review early in construction with GC to know special requirements and submittals	Alert SDR/SCO's to additional requirements in Special Specs			
SUBMITTALS (including shop drawings)	Meets all 1330 and special spec requirements	PM – ensures approved submittals are provided to full distribution.	SE's review courtesy copy in parallel with A/E. Comment as necessary. CxA begins work on checklists.	SCO team compares approved submittals against contract documents & comment as necessary.	Ensures they meet equipment schedule & specs; ensures all submittals are accounted for. Updates log for CxA & SDR	FP – reviews FA & FS shop drawings FCS – reviews HVAC controls & controls equipment schedule to match reqmnts	Review approved submittals 6-8 weeks in advance of expected T&B	Maintenance receives approved submittals, begins updating Master Equipment List (MEL). Develops MEL if new building.

	GC&SUBS	PM and/or CM	SE's and/or CxA	SDR/ITL & SCO's	A/E firm	FCS or Fire Protection	T&B (and/or other contract test firms)	BMT (BM or Maintenance)
COORDINATION DRAWINGS	Use to ensure that installation meets maintenance access requirements	CxA – QA review	QA review and feedback to A/E	References final set during installation verification phase	A/E prepares, to make sure equipment has necessary maintenance access			QA review and feedback to A/E
Cx TEAM MEETINGS	GC attends each meeting and Mech & Elec subs attend at least monthly, and weekly beginning with pre-functional check phase	PM – provides minutes of each meeting.	CxA – plans agenda for each meeting; holds Cx kickoff mtg, discusses team roles & responsibilities. MSE & ESE attends each meeting	Attends each meeting	Attends as requested	Attends at least monthly, and then weekly beginning with equipment start-up phase.	Attends as requested, and at least 1-2 times before anticipated T&B	Attends at least monthly
SCHEDULE	Master CPM provided per Specs. Updates at least monthly and incorporates Cx milestones (e.g., start-up plan, T&B, FTP's, training)	PM/CM makes sure that schedule & updates are provided & it reflects and accommodates Cx requirements.	CxA – provides copy of schedule to Cx team members. Ensures schedule shows Cx milestones.	Notifies T&B firm (& other test agencies), & FCS of their date range in schedule				
DESIGN INTENT DOCUMENT (DID)		PM – makes RFI & CO log available, to ensure DI document is up-to-date.	Review to ensure it meets need & for input to develop FTPs	SDR – QA review	Updates DI document as necessary (re: AEN Submittals, RFIs & CO's)	FCS – Review for better understanding of sequences of operation. FCS begins database & programming.	T&B firm reviews for better understanding of system function	Maintenance team reviews for information

	GC&SUBS	PM and/or CM	SE's and/or CxA	SDR/ITL & SCO's	A/E firm	FCS or Fire Protection	T&B (and/or other contract test firms)	BMT (BM or Maintenance)
INSTALLATION VERIFICATION	Working copy of I,O&M manuals on-site prior to equipment install. QC that equipment & devices installed per spec, dwgs, code, OEM and approved submittals.		Develop checklists for installation verification and pre-functional checks. Use I,O&M manuals to customize. Draft FTPs. CxA (delegated to SDR) – QA that installation verification has occurred according to checklists	SCO – Verify equipment matches approved submittals. Use <i>Big Picture</i> construction checklists to document this phase.		Provide installation checklists to SCO if not included in applicable specifications	T&B firm – share T&B checklist with Cx Team ~2 weeks in advance of expected T&B	
PRE-FUNCTIONAL CHECKS	Meet requirements in specifications (see attached). M & E subs sign off on their Ctrl's and FA installers checklists.	CxA (delegated to SDR) – document the completed checks & provide summary to Cx team		SCO – sign off on certificates of inspection, such as hydro tests. Contact Water treatment SE		FCS – QA that P-t-P verification has been done. FP – QA that FA checklist has been done.	T&B – perform checklist walkthrough	Witness equipment start-ups by manuf. Reps.
FUNCTIONAL TEST PROCEDURES (FTPs)	Subs conduct tests according to procedure	Develop FTP schedule and schedule witnessing. Witness select FTPs	Finalize FTPs and share with Cx team. Determine acceptance criteria <u>before</u> conducting tests. Witness and document FTP results.	SDR & SCOs – Witness select FTPs.	Assist SE in developing acceptance criteria. Witness tests as requested.	Assist SE in developing FTPs and acceptance criteria. Witness select tests. FP – conduct FA acceptance test	T&B is completed prior to FTPs. Draft T&B report is provided to Cx Team.	Witness select FTPs
SUBSTANTIAL COMPLETION (this	Submits complete, tabbed binder				Reviews submitted O&M			

	GC&SUBS	PM and/or CM	SE's and/or CxA	SDR/ITL & SCO's	A/E firm	FCS or Fire Protection	T&B (and/or other contract test firms)	BMT (BM or Maintenance)
may come before or after FTPs)	for O&M manuals per Spec 1330				manuals for completeness.			
CONTRACT CLOSEOUT	Completes punchlist and action items from Cx effort. Submits copies of start-up reports, vibration report, as-builts, etc.	CxA - Review closeout documents for completeness		SDR – Reviews closeout documents for completeness. SDR/SCO arranges training session with Contractor and SNL Maintenance				Participates in final inspection and finalizes Master Equipment List
DOCUMENTATION (this is done since the onset of construction phase Cx)	Provide filled out checklists to SDR		CxA assembles meeting minutes, DI document, completed checklists, all FTP results, records of training & remaining action items into final Cx report	SDR assists CxA in assembling final Cx report		FCS – Assist CxA in assembling final Report	Assembles final T&B report for submittal to SNL & A/E.	
SYSTEMS DEMONSTRATION & TRAINING	Arrange with SDR when all systems are fully functional. Coordinates w/ subs & vendors. Provide training agenda.		CxA – reviews agenda for completeness	SDR – ensures complete O&M binders submitted at least 30 days in advance of demo & training	Reviews O&M manuals for completeness ahead of time	Participates in demo & training		Send craftsmen assigned to building to the training sessions. Review O&M manuals beforehand

	GC&SUBS	PM and/or CM	SE's and/or CxA	SDR/ITL & SCO's	A/E firm	FCS or Fire Protection	T&B (and/or other contract test firms)	BMT (BM or Maintenance)
TURNOVER		PM notifies BMT that project record drawings are available	Receive final Cx report	SDR ensures that final Cx report and other closeout documents are distributed.	Creates final record drawings from GC as-built drawings.			Receive final Cx report. Develops equipment PM schedule, referencing O&M manuals.
WARRANTY PERIOD	Participate as necessary for seasonal equipment Cx		Monitor system performance, work requests, etc., during this period. CxA – ensure that seasonal equipment Cx is accomplished as necessary	Executes the warranty as needed. Schedules walkthrough at 10 months.		Monitor system performance during this period		
LESSONS LEARNED (feedback & improve)		PM schedules lessons learned meeting	CxA conducts meeting	SDR schedules if not done by PM		Attends & gives feedback		Attends & gives feedback