

CECW-CE

Regulation  
No. 1110-345-723

31 March 2017

Engineering and Design  
TOTAL BUILDING COMMISSIONING PROCEDURES

1. Purpose. This regulation provides policy and guidance for developing total building commissioning procedures and executing/documenting commissioning activities for delivering facilities and systems starting with the planning phase and continuing through the post occupancy phase. The objective is to integrate total building commissioning activities into the entire construction delivery process to ensure that systems operate to meet the owner's project requirements and requirements as defined in the construction contract plans and specifications. The previous version of ER 1110-345-723 provided policy and guidance for developing systems commissioning procedures. The primary focus of ER 1110-345-723 was limited to commissioning of facility HVAC Controls. Current Industry, DOD, and USACE standards and guidance have significantly expanded the commissioning scope required for USACE projects.
2. Applicability. UFC 1-200-02 references ASHRAE 189.1, section "Building Project Commissioning", as the commissioning requirement for new construction, new additions and renovations. It is important to note, that for renovations, only the systems that are replaced must be commissioned; however, commissioning efforts should include verification of how new systems integrate with existing systems. Total Building Commissioning includes commissioning of a variety of building systems, not just HVAC systems, and establishes the required level of effort for commissioning on projects. This regulation applies to the following:
  - a. All Military Construction Army (MCA) projects executed by USACE that are subject to any of the referenced documents regardless of location (CONUS/ OCONUS) that include over 5,000 gross square feet (GSF) of interior space and the construction cost is greater than \$3 million.
  - b. For overseas construction activities on permanent basing and overseas construction activities in support of contingency operations, this policy will apply to the greatest extent practical considering mission objectives and Host Nation agreements.
  - c. For projects in support of others (i.e., other military services and DOD and federal agencies, vertical construction for USACE civil works projects), where USACE is the design and/or construction agent, this regulation applies to the extent Total Building Commissioning has been included in the programming documentation/funding.

31 Mar 17

Exception: If a building is 5,000 GSF or less, ASHRAE 189.1, section Building Acceptance Testing, is sufficient and additional commissioning requirements indicated hereinafter are not applicable.

3. References.

- a. AR 420-1, Army Facilities Management
- b. ER 5-1-11 USACE Business Process
- c. ER 25-345-1, Systems Operation and Maintenance Documentation
- d. ER 37-1-30, Financial Administration – Accounting and Reporting
- e. ER 414-345-38, Transfer and Warranty
- f. ER 415-1-10, Contractor Submittal Procedures
- g. ER 415-1-11, Biddability, Constructability, Operability, Environmental, and Sustainability Review (BCOES)
- h. Memorandum, ASA (IE&E), 16 Dec 2013, subject: Sustainable Design and Development Policy Update
- i. ANSI/ASHRAE Standard 202-2013, The Commissioning Process for Building and Systems
- j. ASHRAE Guideline 0-2013, The Commissioning Process
- k. ASHRAE Guideline 189.1-2014, Standard for the Design of High Performance Green Buildings, Section 10 Construction and Plans for Operations
- l. Federal High Performance and Sustainable Buildings Guidance, 1 Feb 2016
- m. Unified Facilities Criteria 1-200-02, 1 Dec 2016, subject: High Performance and Sustainable Building Requirements
- n. U.S. Green Building Council (USGBC) LEED Reference Guide for Green Building Design and Construction 2009 Edition

4. Background. Designers must effectively convey the building's intended operation, as defined by the Owner's Project Requirements (OPR), into the plans and specifications. Total Building Systems Commissioning performed to verify that the OPR and design intent have been achieved, as expressed in the plans and specifications, is a necessary element for true beneficial use of any project. Operation and maintenance functions are enhanced when all of the responsible parties are cognizant of contract compliance, construction quality, and performance and operational

parameters of the systems. The importance for a disciplined approach to systems commissioning is intensified as the cost, complexity, uniqueness, and magnitude of the project, system or process involved increases. The need is further intensified by the interdisciplinary interactions of the various systems comprising the entire project. The concept and practice of total building commissioning is recognized by the building design and construction industry as described in ASHRAE GUIDELINE 0 and ANSI/ASHRAE Standard 202 which provide procedures, and methods for verifying and documenting the actual performance of building systems and evaluating their conformity with the owner's project requirements (OPR) and basis of design (BoD). ASHRAE Guideline 0 covers the Total Building Commissioning Process and describes each phase of the project delivery from pre-design through occupancy and operation. This ER provides appendices to be used as tools in planning and executing the total building commissioning process.

## 5. Guidance.

a. **General.** Total Building Commissioning (TBCx) is a process which is documented in a Commissioning Plan (CP) and involves achieving, validating, and documenting the performance of facility elements/systems for conformance with the Owner's Project Requirements (OPR), Basis of Design (BoD), and Construction Documents/Contract Documents (CD). It involves engagement of the Commissioning Authority and Commissioning Team during pre- design, design, construction, and occupancy and warranty phases. As a minimum, the using agency, design agent and construction agent will all actively participate in identifying and developing Total Building Commissioning requirements. Refer to Appendix A for guidance in implementing the overall Total Building Commissioning process.

b. **Commissioning Leadership Structure.** The building design and construction industry uses the term "Commissioning Authority" (CxA), as defined in ASHRAE guideline 0, to refer to the "entity identified by the Owner who leads, plans, schedules, and coordinates the commissioning team to implement the Commissioning Process." USACE, as a Design and Construction Agent, represents the Owner's interests with respect to commissioning. Therefore, for projects executed by USACE requiring commissioning, USACE is designated as the Commissioning Authority (CxA) providing oversight assurance of the entire commissioning process. In the context of USACE design and construction processes, certain Cx roles and responsibilities are assigned to other entities and/or lead individuals in contractual relationships with USACE, while USACE still maintains overall Cx process oversight. The leadership structure of the Commissioning Team, including roles and responsibilities, must be fully defined in the Commissioning Plan (CP), as the structure may vary depending on the acquisition strategy, size, expertise of the participants, and complexity of the project. Since USACE's role as the CxA involves the delegation of certain activities, to help understand these delegated roles and responsibilities, a Commissioning leadership structure has been defined below. In addition to the requirements defined herein, individuals within the commissioning leadership structure must have the appropriate qualifications for LEED documentation purposes when applicable. The Commissioning Specialists defined below may also be supported by discipline specific specialists, as dictated by the size and complexity of the project.

(1) Commissioning Specialist for the Government (CxG)

(a) The CxG is the lead individual, employed by the Design and Construction Agent, but not affiliated with the construction contractor, and is responsible for government oversight of the commissioning process. The CxG shall have expertise in the commissioning of facilities of type of similar scope and complexity comparable to the individual project. The CxG is required for all project procurement methods. The CxG is supported by other commissioning specialists/team members as necessary.

(b) For the purpose of meeting USGBC's LEED Rating system EA Credit 3, "enhanced" Cx requirements, the CxG is considered the CxA for Design-Bid-Build (DBB) and for Design-Build (DB) projects. When LEED certification EA Credit 3 is being pursued from USGBC or any other 3<sup>rd</sup> party certification process, the CxG must possess the required applicable qualifications.

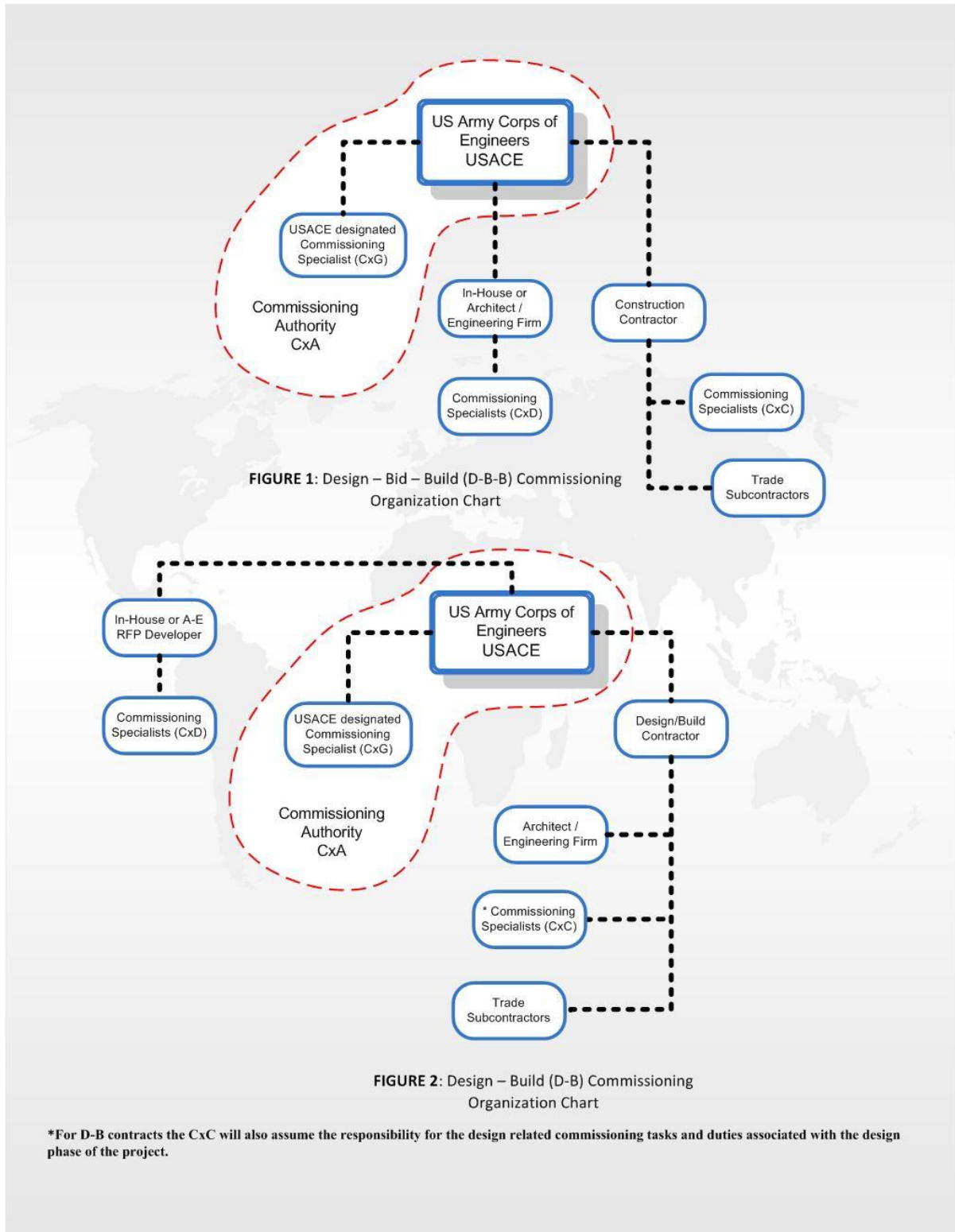
(2) Commissioning Specialist for the Design Phase (CxD). The CxD is the lead individual on the Design A/E staff, an employee of a commissioning firm directly contracted by the A/E, or for in-house projects, can be on the in-house USACE design staff, having expertise in the commissioning process for facilities of a scope and complexity comparable to the individual project, and is responsible for the commissioning activities during the design phase. The CxD is required for Design-Bid-Build (DBB) projects, and during Design-Build (DB) RFP preparation for DB projects. For projects for which in-house personnel are fulfilling the role as CxG, they may also be designated as the CxD during the design/RFP development phase. The CxD is supported by other commissioning specialists/team members as necessary.

(3) Commissioning Specialist for the Construction Phase (CxC). The CxC is the lead individual, employed by a commissioning firm, responsible for managing, scheduling, executing, and documenting commissioning activities for the duration of the construction contract. Both the commissioning firm and the CxC must be certified commissioning providers with the experience and expertise in the commissioning of facilities of comparable scope and complexity. Acceptable commissioning certification programs shall be as defined in the latest Unified Facility Guide Specifications (UFGS). The CxC must also be employed regularly in building commissioning. Generally, the CxC shall be employed by a commissioning firm that is a first tier subcontractor hired by the construction contractor, and is supported by other commissioning specialists employed by that firm; however, as determined by the Authority Having Jurisdiction (AHJ), in consideration of the size, scope, and complexity of the project, with requisite experience and qualifications, the CxC may be an employee of the prime construction contractor. The CxC in a Design-Build Acquisition will also assume the responsibility for the design related commissioning tasks and duties associated with the design phase of the project. The CxC is required for all projects.

c. Roles and Responsibilities. Roles and responsibilities related to Total Building Commissioning are interwoven and complex and can vary based on the acquisition strategy, project size and complexity, and available resources. Roles and Responsibilities must be documented in the Cx Plan. Refer to Appendix C, the sample roles and responsibilities matrix which is provided to assist in identifying those roles and responsibilities for the required tasks to be executed. The Responsibility and Accountability Matrix highlights the task description, the

level of involvement and the personnel for each task. Many tasks have several people involved. The level of involvement is defined as: lead, participate, approve, and/or review. The list of roles is CxG, Contracting Officer Representative (COR), Designer of Record (DOR), CxD, CxC and Government Facility O&M. The level of participation by each role changes depending on project phase and task. The matrix should be developed during the planning/pre-design phase, but no later than early in the project design phase for DBB or RFP development phase for DB to properly allocate costs among stakeholders. Updates to the Cx Plan would include a review and update of the Roles and Responsibility matrix.

d. Figures 1 and 2 below provide the organizational structure for Design-Bid-Build (DBB) and Design-Build (DB) acquisitions. The commissioning team is responsible to assure that the operation of the final constructed facility meets the Owner's Project Requirements (OPR) and Basis of Design (BoD)/Design Intent; this does not mean that all tasks are performed by one entity or individual. In no way does the designation of a CxG alleviate the Construction Contractor's requirement for a CxC. The Construction Contractor has a significant role in the quality of the building systems as well as scheduling and documenting meetings, reports, reviews, functional tests and operator training. USACE provides the oversight and executes commissioning through its established processes. Depending on the size and complexity of the project, where appropriate and required to supplement its geographic in-house personnel, USACE may seek out resources from outside its geographic region or contract with a private enterprise to execute the roles and responsibilities of the CxG. In all cases, the Construction Contractor provides for a CxC for further detailed development, execution and completion of the Commissioning Plan which includes development of pre-functional construction checklists and functional performance testing procedures for the actual submitted systems and equipment. The CxC provides all reports to include the final summary Commissioning Report that validates compliance of the constructed facility with construction documents.



Figures 1 and 2 Total Building Commissioning Process Commissioning Organization Roles & Responsibilities for D-B-B and D-B Acquisitions

e. **Systems to be Commissioned.** The extent of total building commissioning, must be established early in the planning/design process. The determination shall be made on a project specific basis. The procedures established in AR 420-1, Chapter 4 "Army Military Construction and Nonappropriated-Funded Construction Program Development and Execution" must be followed to properly identify and program the necessary planning and design resources and construction funding requirements. The systems and equipment to be commissioned and the Commissioning Team roles and responsibilities will be outlined in the Commissioning Plan during the planning and design process and further refined and detailed throughout all phases of the project. The Commissioning Plan (CP) shall be inclusive of the following systems as indicated in ASHRAE 189.1, if included in the project, determined to be required based on complexity and size of the building, and required by the latest UFC 1-200-02 or SDD Policy: HVAC, indoor air quality, refrigeration, building envelope, lighting controls, fenestration control, irrigation, plumbing, domestic and process water and pumping, service water heating, renewable energy system, water measurement devices, energy measurement devices and other systems (e.g. emergency power, electronic communication systems, medical gas systems, elevators, etc.), as warranted and required by the Authority Having Jurisdiction (AHJ).

6. **Implementation of Total Building Commissioning.** The using agency, design agent, and construction agent shall actively participate as a team during the planning, design, construction, and post occupancy/warranty phases as outlined herein. The particular resources and responsibilities shall be documented in the Project Management Plan (PMP) that is specifically developed for that project. Minimum requirements of a PMP are described in ER 5-1-11 USACE Business Process.

a. **Funding and Resourcing.** Funding sources cross functional lines and cross over the phases of the project. The Project Manager must be engaged in identifying, requesting, tracking and managing funding so that no interruptions of commissioning services occur. Commissioning costs must be validated during the parametric design process (i.e., ENG Form 3086 preparation) in order to ensure that sufficient funds are available to execute commissioning in compliance with Army requirements.

(1) It is expected that the using agency will fund the participation of its own personnel in the commissioning activities. For USACE costs associated with commissioning, funding shall be in accordance with the activities performed.

(2) Prior to award of the construction contract (DB and DBB), design phase commissioning activities for the CxD, CxG, and Designer of Record (DOR) shall be funded with appropriate Planning and Design (P&D) resources.

(3) Post construction contract award, the following funding resources are available: Design During Construction (DDC) (also referred to as Engineering During Construction (EDC)), Supervision and Administration(S&A) and project construction funds.

(a) For DBB, DOR commissioning activities shall be funded by DDC resources. For DB, DOR commissioning activities shall be funded by project construction funds (i.e., as part of the construction contract).

31 Mar 17

(b) For DBB and DB, CxG commissioning activities shall be funded by DDC or S&A resources as appropriate for the tasks, in accordance with ER 37-1-30, Chapter 22. CxG tasks related to design review and extensions of design (e.g. activities involving verification that OPR and BoD are being achieved, design review, activities that also include participation by or performed by the DOR, etc.) are funded by DDC. CxG tasks related to ensuring that quality assurance of commissioning activities (e.g. inspection of installation and completion of pre-functional checklists) are funded by S&A resources. When commissioning is programmed as a line item on the DD Form 1391 separate from the construction contract cost, those project construction funds shall be used for CxG commissioning activities. For DBB and DB, Construction quality assurance (QA) personnel commissioning activities shall be funded with S&A resources.

(c) For DBB and DB, Construction contractor and CxC activities associated with executing the commissioning process during construction must be included as contract requirements and therefore would be funded with project construction funds. These costs are not additional costs. Costs would be included on the DD Form 1391 and Form 3086 as a part of the Primary Facilities Construction Contract Costs. Costs for this Contractor's Commissioning Specialist should already be included within the DoD Unit Costs for a majority of the systems included on a project per the previous requirement to meet LEED Fundamental Commissioning. Additional systems newly required by ASHRAE for Total Building Commissioning are expected to be relatively minor in comparison and could be included as a part of the SDD 2% line item and used as justification to keep this line item in the future. If the team feels that there are specialty systems, not normally covered they should be requested by the 3086 phase.

b. Participation.

(1) The USACE District, in its capacity as design agent, shall ensure that the design SOW requires the design services necessary to develop contract commissioning specifications using the guidelines in Appendix A and available commissioning United Facilities Guide Specifications (UFGS). The CxG and CxD shall ensure that total building commissioning requirements are included in the construction contract and that they will result in verification of the OPR and BoD. District Quality Management Programs document the assurance procedures used to verify total building commissioning requirements are adequately addressed in the contract documents. The review and certification processes established by ER 415-1-11 will serve to document both the design and construction agent's acceptance of the total building commissioning requirements prior to project advertisement and/or bid opening. Additionally, Districts must ensure appropriate project/DDC funding of and participation by the DOR and CxG after construction contract award during execution of applicable commissioning activities.

(2) The USACE District, in its capacity as construction agent, shall ensure that the construction contractor provides all necessary labor, services, and materials to allow the CxC to manage, execute, and document the total building commissioning requirements. District Construction Quality Assurance Programs document the assurance procedures used to verify contractor compliance with these requirements. Additionally, Districts must ensure appropriate participation by the DOR and appropriate S&A funding of and participation by the CxG after construction contract award during execution of applicable commissioning activities.



31 Mar 17

(3) The using agency, in its capacity as user/owner/operator and ultimate stakeholder, should make a continuous corporate commitment to the total building commissioning process. The using agency's participation begins early in project development defining the OPR, and requires continuous representation throughout the planning, design, construction, acceptance, and post occupancy/warranty phases. While USACE, as the CxA, is ultimately responsible for a fully functional project, the using agency must convey their commissioning concerns and functional requirements clearly and early on a project specific basis as defined in the OPR, and participate in witnessing and determining acceptability of commissioning results. USACE and the using agency must work together in developing realistic and reasonable total building commissioning requirements and to maximize using agency participation in training sessions.

c. Schedule of Commissioning Activities. Commissioning is an ongoing process that starts with the planning phase and continues through post occupancy/warranty phase. Commissioning activities for each phase must be integrated into the overall project schedule. Particular attention must be provided to scheduling of commissioning activities during the construction phase to ensure that the construction contractor has adequately planned for and that commissioning activities are included into the overall Integrated Master Schedule (IMS), to include activities involving government participation. For a sample construction activity flow chart Refer to Appendix D.

d. Final Acceptance. When requirements of the commissioning plan have been successfully completed and satisfactorily documented in the final commissioning report, the CxC, CxG, and DOR (as applicable) recommend final acceptance of the facility to the COR.

FOR THE COMMANDER:



PAUL E. OWEN  
COL, EN  
Chief of Staff

4 Appendices  
Appendix A Guidelines for the  
Commissioning Process  
Appendix B Definitions  
Appendix C Sample Roles and Responsibility Matrix  
Appendix D Commissioning Scheduling Process

THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX A

## GUIDELINES FOR THE TOTAL BUILDING COMMISSIONING PROCESS

1. Purpose and Scope. These guidelines provide procedures and methods for documenting and verifying the performance of systems provided in USACE projects so that systems operate in conformity with the owner's project requirements (OPR) and basis of design (BoD). Refer to appendix B for definitions.

2. Applicability.

a. These guidelines are intended for use by all members of the design, construction, commissioning, and operation team which include: the using agency planners, mission and O&M staff, USACE project management, engineering and construction staff, and the designer of record (DOR). Support and information will be necessary from the contractor, suppliers and others as may be applicable to a given project. The commissioning process extends through all phases of the project: Planning/Pre-Design, Design, Construction, Acceptance, and Post Occupancy/Warranty. The end result should be fully functional, integrated and coordinated building systems.

3. Planning/Pre-Design Phase.

a. Introduction. The objective of this phase is to establish the overall commissioning effort for the project and ensure resources are planned to execute that effort.

b. Planning/Pre-Design Phase Activities.

(1) During this phase, a planning and/or design charrette is conducted to develop the project scope, to include the level of rigor of total building commissioning based on the size and complexity of the project, and the Owner's Project Requirements (OPR). The Planning Charrette teams should include a member knowledgeable in the Total Building Commissioning process.

(2) Anticipated systems to be commissioned within the project should be identified. If design costs above the typical level are anticipated (e.g. additional OPR and/or design reviews by a contracted (CxG), the additional P&D costs shall be identified, along with any other special design instructions developed during the DD 1391 review process. This will alert Programs Management Division (at HQUSACE) of the need to provide additional P&D funds in the design directive.

(3) The cost for commissioning services beyond our current quality control/quality assurance processes which are already included in the DoD Unit Price with justification and approval from ACSIM, are estimated and incorporated into the DD Form 1391 and/or the ENG Form 3086 as a separate line item. DoD Unit Price for facilities is an average price based on several years of actual Federal construction project costs. Building projects have historically incorporated the requirements for LEED Fundamental Commissioning and the requirements of Engineering

31 Mar 17

Regulations (References c and d) which represent many of the tasks of Total Building Commissioning. The costs included in the DD Form 1391 and/or ENG Form 3086 must reflect only those services beyond the requirements of LEED Fundamental Commissioning and Engineering Regulations. Such costs may include, but are not limited to:

(a) Commissioning services for additional systems to be commissioned, to include integrated systems testing, and activities beyond those required by LEED Fundamental Commissioning.

(b) Additional design and construction submittal reviews performed by a designated CxG for purposes of verifying OPR is being met.

(c) Post occupancy building systems evaluation by a designated CxG.

c. Documentation. The Owner's Project Requirements (OPR). At this stage, the OPR is comprised of the charrette meeting notes which must be included in Tab C of the final DD Form 1391. During parametric design process, the notes must also be included in the PDR Report (ENG Form 3086). If an initial Commissioning Plan (CP) is developed during this phase (which may not be feasible due to funding and/or available resources), it shall document the expected activities, systems to be commissioned and designated roles and responsibilities of the Commissioning Team. It is recommended to utilize the appendices of this ER as tools to develop the initial Commissioning Plan (CP).

#### 4. Design Phase.

##### a. Introduction.

(1) The objective of this phase of commissioning is to outline the scope of requirements for each system whose performance is to be verified, with a comprehensive commissioning process. This phase is performed by the CxD (from Architect-Engineer or USACE in-house design team with input from the user, and review by the CxG and other USACE engineering and construction elements. Additionally, the design phase is applicable to the DB RFP development phase with the CxD as the lead Cx specialist and continues after DB construction contract award with the CxC as the lead Cx specialist.

(2) Early in this phase, designate the CxG that will have oversight responsibilities to assure the execution of the commissioning process. While Total Building Commissioning is a team effort, it is a best management practice to have continuity of the CxG from the beginning of a project to the end, if possible.

##### b. Design Phase Activities.

(1) The following detailed requirements for commissioning are developed: The Owner's Project Requirements (OPR), The Basis of Design (BOD), Design Phase Commissioning Plan, and Construction Contract Requirements.

(2) The CxG and CxD shall conduct a commissioning design review of the OPR, BoD, and

design documents at each design deliverable milestone, e.g. 35%, 65%, 95%, 100%, and back check review comments at the subsequent review submissions. This review shall be documented as part of the commissioning process.

c. Documentation.

(1) Owner's Project Requirements (OPR). The OPR document will be developed at this phase, prior to construction contract award, by the designer of record (DOR) for DBB projects or RFP preparer for DB projects and the CxD with the owner to describe the project's goals and specific functional and operational requirements for the commissioned systems. Prepare the OPR document by compiling information related to the systems to be commissioned from the DD Form 1391, PDR (ENG Form 3086), design charrette minutes, and applicable criteria, standards and guidance. Refer to ASHRAE STD 202 for outline of an OPR. The OPR is reviewed by the CxG.

(2) Basis of Design (BoD). The BoD will be developed at this phase by the design team with review by the CxD (or CxC for DB projects, CxG, and using agency. The BoD includes design criteria, codes, standards and assumptions, and a narrative description of each system selected, the rationale for system selection, and the intended operation and expected performance of each system. Refer to ASHRAE STD 202 for outline of a BoD.

(3) Design Phase Commissioning Plan. When an initial commissioning plan is developed during the planning phase, it shall be used as the basis for the design phase commissioning plan. The CxD shall develop the design phase commissioning plan for the DBB project design phase. The CxD shall develop the design phase commissioning plan for the DB RFP development phase. The CxC shall develop the design phase commissioning plan for the DB contract design phase which shall include the requirements in the DB construction contract specifications. The design phase commissioning plan must detail the implementation of the commissioning process including the following:

(a) Overview of the commissioning process developed specifically for the project.

(b) List of the systems to be commissioned.

(c) The entities involved at various stages of the commissioning process, i.e. the commissioning team, which will include the CxG, CxD, user, designers, CxC and support technical commissioning specialists, contractors, manufacturers, and others as required and designated roles and responsibilities of each entity. Include the Sample Roles and Responsibility Matrix in Appendix C edited specifically for the project.

(d) Documentation of general communication channels, including the distribution of the design phase Commissioning Plan during the design and construction process.

(e) Detailed description of design phase Cx process activities and a schedule of activities.

31 Mar 17

(f) Project design documentation evaluation procedures, e.g. BCOES, ITR, CxG review, etc. processes.

(g) General description of Cx process Activities that will occur during construction and occupancy/operations. Include general guidelines for scheduling the participation of the operations and maintenance personnel during the construction phase and the subsequent phases of the commissioning process.

(h) Guidelines and format that will be used to develop the Cx Process documentation, including systems manual and training plans.

(i) Listing and format for checklists and testing forms, issues and resolution log, and Cx Progress Reports that will be used during the project to communicate and track critical Cx Process information.

(j) The framework for procedures to follow whenever installation and operation do not meet the OPR.

(4) Construction Contract Requirements. The construction phase commissioning requirements shall be detailed in the contract documents, prepared by the DOR and CxD with review by the CxG, using the available UFGS commissioning specifications as a basis. At a minimum, the contract specifications shall contain the following:

(a) A list of systems to be commissioned.

(b) Roles and responsibilities of the Contractor, commissioning firm, CxC, support commissioning specialists, subcontractors, equipment manufacturers, testing agencies, and QC personnel in the commissioning process.

(c) Qualifications of commissioning firm, CxC, and support commissioning specialists.

(d) Sample pre-functional checklists (PFCs) for all equipment to be commissioned to demonstrate level of rigor required.

(e) Sample functional performance tests (FPTs) and integrated systems tests (IST) for all systems to be commissioned to demonstrate the level of rigor required. Every mode of systems operation and all system equipment components should be tested and proved operational under all normal operational modes, including part and full load, and under failure or emergency conditions. This must include every individual interlock and conditional control logic. Temporary upsets of systems, such as distribution fault, control loss, set point change, equilibrium upset, and component failure, should be imposed at different operating loads to determine system stability and recovery time. Acceptable methods of simulation should be described in detail.

(f) Appropriate sampling allowed for each type of similar equipment and systems for performing checks and testing.

(g) Requirements and submittals for calibration for test equipment.

(h) Requirements for incorporation of all commissioning activities in the contractors schedule.

(i) Requirements for commissioning meetings.

(j) Requirements for site observations.

(k) CxC design review requirements for DB projects.

(l) Progress reporting and commissioning issue log requirements.

(m) Submittals and documentation requirements, e.g. construction phase commissioning plan, design phase commissioning plan for DB projects, certificate of readiness, commissioning report, systems manual, etc.

(n) Training plan requirements.

(o) Post occupancy requirements.

(p) Deferred seasonal commissioning requirements

## 5. Construction Phase.

### a. Introduction.

(1) This section describes the commissioning process during the construction phase of the project. In this phase, systems are installed, tested and put into operation. When installation is essentially completed, the systems are ready for pre-functional checks followed by functional performance testing and integrated systems testing as appropriate. The total building commissioning process is necessarily iterative. Deficiencies in one individual system may impact the commissioning of other individual systems as well as the commissioning of the complete project. Deficiencies must be rapidly resolved by the appropriate parties to permit timely completion of the commissioning process.

(2) Commissioning is an ongoing process. It continues through the installation of the systems. In this phase, the contractor performs and documents all tests of equipment, piping, ductwork, wiring, and other subsystems and shall perform all start-up, testing, adjusting and calibration activities, pre-functional checks, as contractually required prior to functional performance testing. The CxC shall verify successful completion of pre-functional checks and that systems are ready for functional performance testing and submit a certificate of readiness.

31 Mar 17

The CxG, DOR, and other commissioning team members shall have the opportunity to witness any or all commissioning activities as part of the contractual quality assurance program. Note that some systems may have contractual requirements for joint witnessing of particular activities.

(3) An important part of the commissioning process is the training of the operations and maintenance (O&M) personnel. Therefore, it is critical that O&M personnel be available at the site at various stages during construction to observe the installation and functional performance testing of systems to learn about how each system functions, system interfaces and applicable operational and maintenance requirements. USACE should proactively encourage O&M personnel participation. The CxC and CxG shall witness and document that the contractor performs training in accordance with the construction contract.

b. Construction Phase Activities.

(1) Commissioning during construction starts with a Commissioning Coordination/kick-off Meeting conducted by the CxC wherein the commissioning process is reviewed with the project team to include the CxG, General/Prime Contractor (GC), other commissioning specialist and representatives, subcontractors, and user representative. Commissioning meetings as required by the contract will be conducted throughout construction to plan, scope, coordinate, and schedule activities and address commissioning related issues. The CxC and CxG attends construction progress meetings as necessary to address commissioning related issues and remain abreast of construction process. Refer to Appendix D for a sample post award Construction Commissioning Activity Flow Chart.

(2) Equipment documentation for systems to be commissioned is reviewed by the DOR, CxG, and CxC through the submittal process in accordance with ER 415-1-10, Contractor Submittal Procedures. Approved submittals are provided to the CxC and CxG.

(3) After submittals have been approved, the subcontractors shall supply additional information regarding manufacturer's installation, start-up, and test procedures, to the CxC for use in finalizing pre-functional checkouts and functional tests which shall be reviewed by the CxG

(4) The CxC, with support from technical commissioning specialists, develops draft equipment and system pre-functional checklists, building envelope inspection procedures, functional performance test procedures, and integrated systems test procedures using samples provided in the construction contract specifications as a starting point ensuring that they incorporate the level of rigor required by the commissioning specifications. The CxG and Subcontractors review the checklists procedures and provide comments for incorporation by the CxC.

(5) The subcontractors develop startup plans and provide to the GC who will forward to the CxC and CxG. The GC will incorporate the subcontractors' expected start-up schedules into the master project construction schedule and forward these to the CxC. The start-up procedures precede functional testing.



(6) Considering the actual sequence of construction, the Subcontractors perform initial checkout and startup. Subcontractors shall execute and document the pre-functional checklists in addition to those provided by the manufacturer's representative. The CxC and CxG shall be notified reasonably in advance of and have the opportunity to witness start-up and pre-functional tests of major equipment. Items of non-compliance in material, installation or start-up shall be documented in the construction deficiency list to be addressed by the contractors' quality control (QC) organization. Any non-compliant items which affect progression of commissioning activities shall be documented in the commissioning issues log for tracking by the CxC.

(7) Quality control work, and all other pre-functional checklist items must be successfully completed prior to functional performance testing.

(8) The controls contractor shall perform point to point check outs, performance verification testing (PVT) and run initial trend logs. Controls PVT should be successfully completed prior to functional performance testing and accomplished in accordance with the contract specifications. PVT should include all possible operating conditions and ranges of devices. All system interlocks, interconnections and safety devices should be checked for proper function. All control devices should be adjusted and calibrated. All control settings should be verified by comparing actual input and output values to calculated values. PVT report and trend logs shall be submitted to the CxC and CxG for recommended approval by both prior to functional performance testing.

(9) All testing, adjusting and balancing (TAB) and duct leak testing (DALT) work should be completed by the TAB contractor with reports submitted and reviewed by the DOR with recommended approval prior to functional performance testing. (Any reference to TAB hereinafter includes DALT if DALT is a requirement of the contract.)

(10) The CxG and other commissioning team members shall have the opportunity to witness any or all start-up, testing, balancing and calibration activities which are performed as part of the contractual quality control program. The CxC shall verify that all pre-functional checklist items are completed prior to functional performance testing.

(11) Once the start-ups and pre-functional tests are complete, subcontractors shall correct deficiencies. After the start-ups and pre-functional tests are accepted by the CxC and CxG, and PVT and TAB have been successfully completed as documented by approved reports, the subcontractors and GC shall schedule the functional tests. A Certificate of Readiness must be provided prior to starting the FPTs in the acceptance phase and shall be signed by the general contractor's QC manager, subcontractors, installers, and CxC certifying that the systems, subsystems, equipment, and associated controls are ready for functional testing. Completed PFCs shall accompany this certificate.

(12) Each system operation description must be updated by the DOR to incorporate design changes that occurred prior to or during the construction phase for use by the CxC in the Acceptance Phase for compiling the Systems Manual.

31 Mar 17

c. Documentation. The commissioning UFGS describes the construction phase commissioning related documentation required to be provided by the GC and the CxC. This documentation includes certifications of the qualifications of the Commissioning Firm, the lead commissioning specialist (CxC), and support technical commissioning specialists, construction phase commissioning plan, commissioning issues log, certificate of readiness, design review report, and training plan. Additional construction phase documentation which support commissioning activities are indicated in other UFGS and listed below.

(1) Construction Phase Commissioning Plan. Prepared by the CxC, it must detail how the commissioning process will be organized, scheduled and documented during the construction, acceptance and post/occupancy/warranty phase. The commissioning UFGS describes the content of the construction phase commissioning plan, which includes an interim and final construction phase commissioning plan.

(2) Interim Construction Phase Commissioning Plan. Prepared by the CxC with support by technical commissioning specialists, it identifies the commissioning and testing standards and outlines the overall commissioning process, the commissioning schedule, the commissioning team members and responsibilities, lines of communication, documentation requirements for the construction phase of the project.

(3) Final Construction Phase Commissioning Plan. Prepared by the CxC with support by technical commissioning specialists, it includes the Pre-Functional Checklists, Functional Performance Test Checklists, and Integrated Systems Test Checklists for each system required to be commissioned, and for each component.

(4) Commissioning Issues Log. This log, maintained by the CxC, describes design, installation, and performance issues that require follow-up action, are at a variance with the contract documents, or have been identified as deficiencies. The issues log will identify and track issues as they are encountered, documenting the status of unresolved and resolved issues. The CxC will review this issues log with the contractors and subcontractors, and CxG, on a regular basis, provide additions and deletions as appropriate. The use of a web-based issues log capable of capturing real-time updates is preferable.

(5) Equipment Submittals. The CxC, CxG, and other Commissioning team members/commissioning specialists will review and provide comments to the Contractor on the construction submittals for equipment and system to be commissioned to ensure they meet the specified performance requirements.

(6) Completed HVAC Controls Performance Verification (PVT) Report.

(7) Completed Testing, Adjusting, and Balancing (TAB) Report.

(8) Completed Pre-Functional Checklists (PFCs) signed by the applicable subcontractor(s), installer(s), QC manager, and CxC.

(9) Certificate of Commissioning Readiness. This certificate shall be signed by the general contractor's QC manager, subcontractors, installers, and CxC certifying that the systems, subsystems, equipment, and associated controls are ready for functional testing. Completed PFCs shall accompany this certificate.

(10) Operations and Maintenance Manuals. Contractors shall provide O&M manuals for all equipment which shall be reviewed by the CxC. Contractors shall update and reissue the manuals as needed.

(11) Training Plan. The GC and subcontractors provide a training plan and proposed materials in accordance with the contract documents. The CxC reviews and comments on the Contractors training materials that in turn modify the plan and materials as appropriate.

## 6. Acceptance Phase.

a. Introduction. The acceptance phase of the commissioning process begins after receipt of Certificate of Readiness. This phase occurs as part of the duration of the construction contract, and as such, may be considered as part of construction phase commissioning as indicated in the commissioning UFGS. It is delineated here as a separated phase as it occurs after most physical construction has been completed and systems are ready to be tested.

b. Acceptance Phase Activities Functional Performance Testing. The functional test procedures are executed by subcontractors at the direction of the CxC and results are documented by the CxC. The CxC shall witness all tests, The CxG and/or designated CxG representative shall witness all tests. Other Cx team members shall witness certain tests, at the request of the CxC and/or CxG, and may witness any other tests.

(1) The functional performance test checklists, developed by the CxC and approved by the CxG, contained in the approved Commissioning Plan (CP) should be used to document the results of the functional performance testing process.

(2) The functional performance testing process should be accomplished for all equipment, subsystems, systems and system interfaces. There may be several similar pieces of equipment, systems, etc., on a project. The project commissioning specifications must define what sampling of similar equipment/systems must be tested for acceptance based on size and complexity of systems.

(3) As each individual check or test is accomplished, the commissioning team should observe the physical responses of the system and compare them to the specified requirements to verify the test results. The actual physical responses of system components must be observed. The input and output signals for each control component also need to be observed to confirm they are correct for each physical condition.

(4) Functional performance testing should progress from equipment or components through subsystems to complete systems. Functional performance testing will have to consider

31 Mar 17

sequences of testing, starting with components and progressing towards complete systems. As a result, the causes of any functional problems should be easier to locate and correct.

(5) The specific tests, and the most efficient order of testing, will vary widely depending on the type of system, the number of systems, the sequence of construction, the relationship between building systems and specific tenant work, the degree of interaction between systems, the complexity of the controls sequence, the impact of system failures on health or safety and other factors.

(6) Equipment and Subsystem Functional Performance Tests. Operate the equipment and subsystems through all specified modes of control and sequences of operation. Include full and part load and emergency /failure conditions, as required by the contract specifications and the construction phase commissioning plan.

(7) Following the equipment and subsystem functional performance testing, the overall systems must receive functional performance testing. Each system must be operated through all modes of operation, safeties, interlocks, load conditions and disturbances, in accordance with the contract specifications and the construction phase commissioning plan.

(8) Integrated Systems Tests (IST). When the functional performance of all individual systems has been proved, the interface or coordinated interaction responses with other systems should be checked, e.g. interface between air systems and fire alarm system, interaction of HVAC system and emergency power, etc.

(9) Deferred Functional Performance Testing. If any test or performance check cannot be accomplished due to insufficient load, lack of occupancy or for other seasonal reasons, this fact should be noted along with an indication of when the test will be re-scheduled. If any check or test cannot be accomplished due to building structure or other building system deficiencies outside the scope of the systems work, these deficiencies should be resolved and corrected by the appropriate parties before completion of the commissioning process. Every check or test for which acceptable performance cannot be achieved should be repeated after the necessary corrective measures have been completed. This retesting process shall be repeated until acceptable performance is achieved.

(10) Corrective Measures. If acceptable performance cannot be achieved, then the necessary corrective measures should be carried out. The CxC, CxG and designer of record may be used to assist in diagnosing the cause of problems and should always provide recommended solutions to design deficiencies. The solutions to significant problems should be approved by the COR through advisement by commissioning team, including the CxG, CxC, DOR and user. The COR must issue appropriate directions for corrective measures, through proper contractual channels.

c. Documentation. Commissioning documentation should be prepared by the CxC and submitted to the CxG and DOR at the completion of the commissioning process. This documentation should include completed FPT and IST checklists, commissioning report, and systems manual.

(1) FPT and IST Results. The CxC will record the result of each individual check or test on the pre-approved test and report form, indicating acceptability or non-acceptability of the results. The following must be recorded at a minimum:

- (a) Name and identification of component/equipment/system.
- (b) Indication of test parameters and final results to include test date and time.
- (c) Signatures of the team members performing the test.
- (d) List of individuals present during test.
- (e) Deficiencies and corrective actions recommended, as well as the time frame for retesting.

(2) Final Commissioning Report. The final commissioning report must be prepared by the CxC and submitted for review by the CxG and the designer of record, and approval by the COR. The final approved report shall be provided to the Installation. The Cx report shall include an executive summary, the construction phase Commissioning Plan, issues log, correspondence concerning major decisions such as approvals, deferred testing, design changes, etc., and all appropriate completed check sheets and test forms (i.e., results of FPTs), TAB and TAB Verification forms, HVAC controls PVT reports and any other documents related to execution of the commissioning process.

(3) Systems Manual. The systems manual must be assembled by the CxC, or by the Contractor with review by the CxC and, as outlined in ASHRAE Guideline 0, it shall include the following:

- (a) Executive summary.
- (b) Owner's Project Requirements (OPR).
- (c) Basis of Design (BoD).
- (d) System single-line diagrams.
- (e) Equipment performance data from approved submittals related to systems commissioned.
- (f) As-built sequences of operation and as-built control drawings.
- (g) Original and as-builts set points for all systems commissioned.
- (h) Recommended schedule for re-testing with proposed testing forms.
- (i) Recommended schedule for sensor and actuator calibration.

31 Mar 17

(j) Recommended equipment preventative maintenance schedules not included in O&M manuals.

(k) Full equipment warranty information.

(l) Confirmation of completed training for the user, O&M personnel, and occupants.

(m) Ongoing system optimization procedures.

(4) Operator Training. The CxC shall verify that the training program has been completed in accordance with the contract specifications and training plan for all equipment and systems. Operator training should provide a complete overview of all equipment, components and systems with an emphasis on the following items:

(a) Documentation in the final operations and maintenance manuals.

(b) How to use the operations and maintenance manuals.

(c) System operational procedures for all modes of operation.

(d) Acceptable tolerance for system adjustments in all operating modes.

(e) Procedures for dealing with abnormal conditions and emergency situations for which there is a specified system response.

(f) Troubleshooting procedures.

(g) Repair procedures.

(h) Upkeep of the systems manual and associated maintenance documentation logs.

(i) Review of warranties and warranty process.

## 7. Post-Occupancy/Warranty Phase Activities.

a. Introduction. Post occupancy/warranty commissioning is a critical step in ensuring the effective, continuous functioning of a facility's systems. This phase of commissioning starts within the warranty period once the building is occupied and fully operational.

b. Post Occupancy/Warranty Phase Activities.

(1) Deferred Testing. Testing which was deferred during the acceptance phase shall be conducted during this phase during the appropriate outside conditions or building occupancy loading. The results should be documented as a supplement to the commissioning report and systems manual update. Every check or test for which acceptable performance was not achieved

should be repeated after the necessary corrective measures have been completed. This retesting process shall be repeated until acceptable performance is achieved.

(2) Post Occupancy Inspection. A post occupancy inspection shall be conducted by the CxC with participation by the CxG, DOR (as deemed appropriate by the CxG and/or COR), O&M personnel, and occupants to review system operation (to include review of trend log data) and verify system performance and maintenance. This post occupancy inspection can be performed concurrent with the warranty inspection. The CxG and Contractor must resolve all outstanding commissioning issues related to contract compliance and document any unresolved commissioning issues that are possible design deficiencies.

c. Post-Occupancy Commissioning Documentation.

(1) "As-built" documents must be revised to reflect modifications made to any part of the facility or systems.

(2) Any change in usage, set-points, installed equipment, maintenance, loads or occupancy should be documented

(3) Post occupancy inspection results shall be documented in supplement to the construction phase commissioning report, system manual update and submitted to the government.

(4) Final Acceptance by COR. When requirements of the construction phase commissioning plan have been successfully completed and satisfactorily documented, the commissioning CxC, CxG, and DOR should recommend final acceptance of the building systems.

THIS PAGE INTENTIONALLY LEFT BLANK



## APPENDIX B

### DEFINITIONS

**Acceptable Performance:** A component or system being able to meet properly developed and specified design parameters under actual load and/or other properly developed simulated operating conditions. Commissioning goes beyond the normal quality assurance role of ensuring contract compliance, by identifying and correcting design and construction defects which are revealed only by the commissioning procedures.

**Acceptance Phase Commissioning:** Acceptance phase commissioning tasks are executed after construction is substantially complete, all Pre- Functional checklists have been completed and accepted, and Certificate of Readiness has been provided. The main commissioning activities performed during this phase are verification that the installed systems are functional as verified by conducting Functional Performance tests and Government Training.

**Authority Having Jurisdiction (AHJ):** For the purposes of enforcement, clarification and resolution of this ER, the AHJ is the geographic Engineering Chief or designated representative.

**Basis of Design (BoD):** The Engineer's Basis of Design is comprised of two components: the Design Criteria and the Design Narrative, these documents record the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements (OPR) and to satisfy applicable regulatory requirements, standards, and guidelines.

**Certificate of Readiness:** A signed certificate stating that systems are ready for functional performance testing and includes applicable completed pre-functional checklists.

**Checklists:** Lists of data or inspections that should be verified to ensure proper system or component installation, operation and function. Verification checklists are developed and used during all phases of the commissioning process to verify that contract compliance and the Owner's Project Requirements (OPR) are achieved

**Commissioning Authority (CxA):** The commissioning authority (CxA) is defined as the person(s) or entity responsible, on the owner's behalf, for assuring the commissioning process is properly carried out according to OPR and BoD during the life of the project, from Pre-Design Phase through Post Occupancy/Warranty Phase. The CxA assures the required documentation is produced and in the context of the overall total building commissioning process. The CxA does not perform testing; it assures the execution of the commissioning process that includes testing and assures the recording and documenting of the process and its results. The CxA participates as a member of the PDT in the planning and oversees of the Total Building Commissioning process. For MCA projects and tenant facilities on Army installations requiring commissioning, USACE, as the Army's Design and Construction Agent, representing the Owner's interests, is the CxA.

**Commissioning Consultant:** Dependent upon the size and complexity of the project and/or available USACE resources, the need for the services of a consultant may be identified and budgeted at the planning phase. The government may elect to procure the services of a

31 Mar 17

commissioning consultant at the beginning of the design phase. The commissioning consultant as a member of the USACE commissioning team is defined as the person, persons or company responsible to execute or augment the duties, roles and responsibilities of the CxG and is also considered as an extension of the owner's staff. Depending on contract acquisition (DB or DBB) or the complexity of the project, it would not be uncommon for the government to utilize multiple consultants (i.e. one during the programming, pre-design and design phases and another during the construction, acceptance, and post occupancy/warranty phase).

**Commissioning Issue:** Any component or system condition (static or dynamic) that adversely affects the commission-ability, operability, maintainability, or functionality of a system, equipment or component. Any condition that is in conflict with the Contract Documents and/or performance requirements of the installed systems and components.

**Commissioning Plan (CP):** The overall document which captures important decisions about the commissioning process and ensures that everyone understands their responsibilities. The commissioning plan should incorporate or reference the project requirements; identify the projects commissioning goals; identify the Commissioning Authority (CxA) and commissioning team members and their roles; establish the scope commissioning in terms of systems and equipment; outline the major commissioning steps during design, construction, activation and operation; and discusses line of communication and authority. Identify acquisition strategy for commissioning. The plan outlines the expectation of the contractor's organization, scheduling, allocation of resources, documentation, etc., pertaining to the overall total building commissioning process. This plan shall be included as part of the Corps overall Project Management Plan for executing the specific project.

**Commissioning Process:** A systematic approach of ensuring, using appropriate verification and documentation, during the period beginning at the project initiation phase and ending not earlier than 1 year after the date of completion of construction of the facility, that all facility systems and assemblies perform interactively in accordance with the design documentation and intent of the Basis of Design (BoD), and the operational needs of the owner of the facility, including preparation of operation and maintenance personnel. The primary goal of which is to ensure fully functional systems and assemblies that can be properly operated and maintained during the useful life of the facility in accordance with the Owner's Project Requirements.

**Commissioning Report:** The final document which presents the commissioning process results for the project. Cx reports include an executive summary, the commissioning plan, issue log, correspondence, and all appropriate completed check sheets and test forms, TAB and TAB Verification forms, PVT reports and any other documents related to execution of the commissioning process.

**Commissioning Specialist for the Construction Contractor (CxC):** The CxC is the lead individual, employed by a commissioning firm, responsible for managing, scheduling, executing, and documenting commissioning activities for the duration of the construction contract. Both the commissioning firm and the CxC must be certified commissioning providers with the experience and expertise in the commissioning of facilities of a scope and complexity comparable to the individual project. Acceptable commissioning certification programs shall be as defined in the

latest Unified Facility Guide Specifications (UFGS). The CxC must also be employed regularly in building commissioning. Generally, the CxC shall be employed by a commissioning firm that is a first tier subcontractor hired by the construction contractor, and is supported by other commissioning specialists employed by that firm; however, as determined by the Authority Having Jurisdiction (AHJ), in consideration of the size, scope, and complexity of the project, with requisite experience and qualifications, the CxC may be an employee of the prime construction contractor. The CxC in a Design-Build Acquisition will also assume the responsibility for the design related commissioning tasks and duties associated with the design phase of the project. The CxC is required for all projects.

**Commissioning Specialist for the Designer (CxD):** The CxD is the lead individual on the Design A/E staff, an employee of a commissioning firm directly contracted by the A/E, or for in-house projects, can be on the in-house USACE design staff, having expertise in the commissioning process for facilities of a scope and complexity comparable to the individual project, and is responsible for the commissioning activities during the design phase. The CxD is required for Design-Bid-Build (DBB) projects, and during Design-Build (DB) RFP preparation for DB projects. For projects for which in-house personnel are fulfilling the role as CxD, they may also be designated as the CxG and continue that role throughout the life of the project. The CxD is supported by other commissioning specialists/team members as necessary.

**Commissioning Specialist for the Government (CxG):** The CxG is the lead individual, employed by the Design and Construction Agent (USACE) or entity directly contracted by the Design and Construction Agent, but not affiliated with the construction contractor, and is responsible for government oversight of the commissioning process. The CxG shall have expertise in the commissioning of facilities of comparable scope and complexity, and employed regularly in building commissioning. The CxG is required for all project procurement methods. The CxG is supported by other commissioning specialists/team members as necessary. For the purpose of meeting industry's "enhanced" Cx requirements (i.e. USGBC's LEED Rating system, EA Credit 3), the CxG is considered the CxA and is the lead individual responsible for government oversight of the commissioning process.

**Commissioning Specialist:** The commissioning specialist(s) as a member(s) of the commissioning team is defined as the individual(s) responsible for supporting the detailed implementation of the commissioning process executed by the lead specialists, i.e., CxG, CxD and CxC, to include but not limited to: drafting & completion of checklists, perform test procedures, record and document test results, and accomplishes other execution of the Commissioning Process. It is important to recognize that the lead commissioning specialist is supported by a multi-discipline team, except on very small projects.

**Commissioning Team:** The qualified group that will plan and carry out the overall commissioning process. The team is composed of USACE Design Manager (DM), USACE Project Manager (PM), designers (USACE and/or Architect-Engineers), commissioning specialists (USACE and/or Architect-Engineers - CxG and/or CxD), users (facility, tenant, O&M), the Administrative Contracting Officer (ACO) for the construction contract, Contracting Officer's representative (COR) (representing Corps construction, the construction contractor and the contractor's commissioning specialist (CxC), support specialists, Quality Control (QC)

31 Mar 17

Manager and supplemental QC personnel, and subcontractor representatives. The individual participants on the team may change as the design and construction process proceeds. Participation by the user is not mandatory, but the value of this service to the customer is directly proportional to their participation. The Corps Design Manager (DM) is the facilitator/mediator for the team during the design phases. The ACO for the construction contract is the team facilitator/mediator during the construction phase.

**Construction Phase Commissioning:** All commissioning efforts executed during the construction process after the design phase and prior to the Acceptance Phase Commissioning.

**Deferred System Functional Test:** Functional Performance or Integrated Systems Tests that cannot be completed at the end of the acceptance phase due to ambient conditions, schedule issues or other conditions preventing testing during the normal acceptance testing period.

**Designer of record (DOR):** The Architect-Engineer or Corps in-house design group responsible for the design and preparation of contract documents for the construction project.

**Enhanced commissioning:** A term defined by the U.S. Green Building Council's (USGBC) LEED green rating system in the energy and atmosphere subcategory. Enhanced commissioning is achieved when supplemental tasks above Fundamental commissioning are performed as outlined in the LEED Reference guide. It involves engagement of a commissioning authority from pre-design, design, construction, acceptance, and through post occupancy/warranty phases.

**Executive Summary:** A section of the Commissioning Report that reviews the general outcome of the project. It also includes any unresolved issues, recommendations for the resolution of unresolved issues and all deferred testing requirements.

**Functional Performance Testing (FPT):** That full range of checks and tests carried out to determine if all components, subsystems, systems, and interfaces between systems function in accordance with the BOD, as identified in the contract documents. In this context, "function" includes all modes and sequences of control and operation, all interlocks and conditional control responses, and all specified responses to abnormal emergency conditions. Functional Performance Tests include static testing, dynamic testing, failure modes, and integrated systems testing. FPT tests are done after all Pre-Functional Checklists are complete and Certificate of Readiness has been provided

**Integrated Systems Test:** A functional performance test intended to verify interaction of two or more systems. Examples include Loss of Power Response Test, Fire Alarm – HVAC Control system for HVAC system shutdown.

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

**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.

**Owner’s Project Requirements (OPR):** A written document that details the project requirements and the expectations of how the building and its systems must be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

**Performance Verification Testing (PVT):** A testing and documentation process that validate the control system(s) operate and function in accordance with the contract documents.

**Planning/Pre-Design Phase Commissioning:** Commissioning tasks performed prior to the commencement of design activities that includes project programming and the development of the commissioning process for the project.

**Pre-Functional Checklist (PFC):** A form used by the Commissioning specialist (Cx) to verify that appropriate components are onsite, correctly installed, set up, calibrated, functional and ready for functional performance testing. Manufacturer’s start-up checklists are not equivalent to PFCs and shall be used to satisfy the contractual requirements for PFCs, but may be included with them. See also Checklists.

**Post-Occupancy/Warranty Phase Commissioning:** Commissioning efforts executed after a project has been completed and accepted by the Government. Post-Occupancy/Warranty Phase Commissioning includes follow-up on verification of system performance, measurement and verification tasks and assistance in identifying warranty issues and enforcing warranty provisions of the construction contract.

**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/Second Season Testing:** See Deferred System Functional Test.

**Systems Manual:** A system-focused composite manual organized by system which contains the information needed to optimally operate the building systems. Much of the Systems Manual is not found in traditional vendor O&M Manuals. For reference, ASHRAE includes all maintenance and design documentation in their definition of Systems Manual. Further, USGBC provides Systems Manual guidance in LEED documentation.

**Total Building Commissioning:** A method or process for delivering buildings or facilities that begins with project inception through one or more years of operation. The process involves a commissioning authority (CxA) that represents the interest of the owner in delivering the

31 Mar 17

building or facility to meet the owner's needs. The objective is to integrate the total building commissioning into existing phases and steps of building design/construction delivery to achieve more benefits for the owner at the same or lower cost. One of the key aspects of total building commissioning is that the owner's needs are determined during the planning and design stage, and then, well-articulated in the plans and specifications, and carried through construction and building occupancy.

User/Using Agency: The organizational groups that combine to provide facilities, perform facility operation and maintenance and perform actual missions at Corps construction project sites. For Army construction this includes the major command, the installation, the Directorate of Public Works and the Tenant.

Whole Building Commissioning: For the purposes of this ER it is the same as total building commissioning.

APPENDIX C

ROLES AND RESPONSIBILITIES MATRIX

Pre-Design Phase(D-B-B)/RFP Development(D-B)		CxG = Gov't Comm Specialist COR = Contracting Officer Rep DOR = Designer of Record CxD = Design Comm Specialist CxC = Construction Comm Specialist O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional N/A = Not Applicable		
Commissioning Roles & Responsibilities		CxG	COR	CxD	DOR	CxC	O&M	Notes	
Category	Task Description								
Meetings	Pre-Design Kick-Off Meeting	P	P	P	L	N/A	P		
	Owner's Project Requirements Meeting	P	P	P	L	N/A	P		
	Commissioning Planning Meetings	P	P	L	P	N/A	O		
Coordination	Coordinate with [COR, DOR, etc.] to ensure that Cx is incorporated into project planning and documents.	L	P	P	P	N/A	O		
Cx Plan & Spec	Draft Commissioning Plan	R	A	L	R	N/A	R		
Schedules	Preliminary Commissioning Schedule	R	A	L	R	N/A	O		
OPR and BOD	Prepare Owner's Project Requirements	R	A	P	L	N/A	P		
	Basis of Design	R	A	P	L	N/A	R		
Commissioning Documents	Identify systems to be commissioned	P	P	L	P	N/A	R		
	Preliminary acceptance criteria	R	P	L	P	N/A	R		
	Commissioning Documents preliminary templates	R	R	L	R	N/A	R		

Note: (Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond what the sample

identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the scope, size, and complexity of the project, the degree of rigor required, and with consideration of available District resources and expertise.

<b>Design Phase (D-B-B)</b>		CxG = Gov't Comm Specialist COR = Contracting Officer Rep DOR = Designer of Record CxD = Design Comm Specialist CxC = Construction Comm Specialist O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional N/A = Not Applicable		
<b>Commissioning Roles &amp; Responsibilities</b>									
<b>Category</b>	<b>Task Description</b>	<b>CxG</b>	<b>COR</b>	<b>CxD</b>	<b>DOR</b>	<b>CxC</b>	<b>O&amp;M</b>	<b>Notes</b>	
Coordination Cx Plan & Spec Schedules	Coordinate with [COR, AHJ, Vendors, etc.] to ensure that Cx interacts properly with other systems as needed to support OPR and BoD	P	P	P	L	N/A	P		
	Preliminary Commissioning Plan	R	A	L	R	N/A	R		
	Preliminary Cx Specifications	R	A	L	R	N/A	R		
	Design Phase Commissioning Schedule	R	A	P	L	N/A	O		
OPR and BoD	Maintain OPR on behalf of Owner	P	P	P	L	N/A	P		
	Review Basis of Design Document vs. OPR	R	P	L	P	N/A	P		
	Maintain BoD on behalf of Owner	P	P	P	L	N/A	P		
Reviews	Focused Concept Design Review	R	L	P	P	N/A	P		
	Focused Design Development (35-50%) Review	R	L	P	P	N/A	P		
	Focused Construction Document Review	R	L	P	P	N/A	P		
	Focused Pre-Final Construction Document	R	L	P	P	N/A	P		
	Focused Final Construction Document	R	L	P	P	N/A	P		
	Final Construction Document Comment Backcheck	R	L	P	P	N/A	P		
Functional	Draft Pre-Functional Checklists (PFC)	R	A	L	R	N/A	R		
Test Protocols	Draft System Functional Performance Tests (FPT)	R	A	L	R	N/A	R		

*Note: (Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond what the sample identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the scope, size, and complexity of the project, the degree of rigor required, and with consideration of available District resources and expertise.*



<b>Design Phase (D-B)</b>		CxG = Gov't Comm Specialist COR = Contracting Officer Rep DOR = Designer of Record CxD = Design Comm Specialist CxC = Construction Comm Specialist O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional N/A = Not Applicable		
<b>Commissioning Roles &amp; Responsibilities</b>		CxG	COR	CxD	DOR	CxC	O&M	Notes	
<b>Category</b>	<b>Task Description</b>								
Coordination Cx Plan & Spec Schedules	Coordinate with [COR, AHJ, Vendors, etc.] to ensure that Cx interacts properly with other systems as needed to support OPR and BoD	P	P	N/A	L	P	P		
	Preliminary Commissioning Plan	R	A	N/A	R	L	R		
	Preliminary Cx Specifications	R	A	N/A	R	L	R		
	Design Phase Commissioning Schedule	R	A	N/A	L	P	O		
OPR and BoD	Maintain OPR on behalf of Owner	P	P	N/A	L	P	P		
	Review Basis of Design Document vs. OPR	R	P	N/A	P	L	P		
	Maintain BoD on behalf of Owner	P	P	N/A	L	P	P		
Reviews	Focused Concept Design Review	R	L	N/A	P	R	P		
	Focused Design Development (35-50%) Review	R	L	N/A	P	R	P		
	Focused Construction Document Review	R	L	N/A	P	R	P		
	Focused Pre-Final Construction Document	R	L	N/A	P	R	P		
	Focused Final Construction Document	R	L	N/A	P	R	P		
	Final Construction Document Comment Backcheck	R	L	N/A	P	R	P		
Functional	Draft Pre-Functional Checklists (PFC)	R	A	N/A	R	L	R		
Test Protocols	Draft System Functional Performance Tests (FPT)	R	A	N/A	R	L	R		

Note: (Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond what the sample identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the scope, size, and complexity of the project, the degree of rigor required, and with consideration of available District resources and expertise.

<b>Construction Phase (D-B-B &amp; D-B)</b>		CxG= Gov't Comm Specialist COR = Contracting Officer Rep CxD = Design Comm Specialist DOR = Designer of Record CxC=Construction Comm Specialist O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional N/A = Not Applicable	
<b>Commissioning Roles &amp; Responsibilities</b>								
<b>Category</b>	<b>Task Description</b>	<b>CxG</b>	<b>COR</b>	<b>CxD</b>	<b>DOR</b>	<b>CxC</b>	<b>O&amp;M</b>	<b>Notes</b>
Meetings*	Construction Commissioning Kick Off meeting	P	P	N/A	O	L	P	
	Commissioning/Issues Resolution Meetings	P	P	N/A	O	L	O	
	Project Commissioning Progress Meetings	P	P	N/A	O	L	O	
	Controls Meeting	P	P	N/A	P	L	P	
Coordination	Coordinate with [COR, AHJ, Vendors, etc.] to ensure that Cx interacts properly with other systems as needed to support OPR and BoD	P	P	N/A	P	L	P	
Cx Plan	Final Commissioning Plan w/ final PFCs and FPTs	R	A	N/A	R	L	R	
Schedules*	Duration Schedule for Commissioning Activities	R	A	N/A	O	L	R	
Doc Reviews*	TAB Plan Review	P	A	N/A	R	P	O	
	Submittal and Shop Drawing Review	P	A	N/A	R	P	O	
	Review Contractor Equipment Startup Checklists	P	A	N/A	O	P	O	
	Review Change Orders, ASI, and RFI	P	A	N/A	R	P	O	
Site Observation*	Witness Factory Testing	P	P	N/A	O	P	O	
	Construction Observation Site Visits	P	P	N/A	O	P	O	

*Note: (Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond what the sample identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the scope, size, and complexity of the project, the degree of rigor required, and with consideration of available District resources and expertise.*

*\*For D-B-B acquisition, DOR participation or review for tasks indicated as optional for the DOR should be determined on a case-by-case basis with consideration of scope and complexity of the project/system, availability of resources, and potential benefit of DOR participation/review; these additional services require funding consideration.*

Acceptance Phase (D-B-B & D-B)		CxA = Commissioning Authority COR = Contracting Officer Rep CxG= Gov't Comm Consultant A/E = Designer of Record CxC = Construction Comm Specialist O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional N/A = Not Applicable		
Commissioning Roles & Responsibilities									
Category	Task Description	CxG	COR	CxD	DOR	CxC	O&M	Notes	
Meetings*	Pre-Test Coordination Meeting	P	P	N/A	O	L	P		
	Issues Resolution and Commissioning Report Review Meetings	P	P	N/A	O	L	P		
Document Reviews*	Review Completed Pre-Functional Checklists	R	A	N/A	R	L	P		
	Pre-Functional Checklist Verification	R	A	N/A	O	L	P		
	Review Operations & Maintenance Manuals	R	A	N/A	O	L	P		
	Training Plan Review	R	A	N/A	O	L	P		
	Warranty Review	R	P	N/A	O	L	P		
	Review TAB Report	R	A	N/A	R	P	P		
	Systems Manual	R	A	N/A	O	L	R		
Site Observations*	Construction Observation Site Visits	P	P	N/A	O	L	P		
	Witness Selected Equipment Startup	P	P	N/A	O	P	P		
Functional Test Protocols*	TAB Verification	P	A	N/A	O	P	P		
	Systems Functional Performance Testing	P	A	N/A	O	L	P		
Reports & Logs*	Final Commissioning Report	R	A	N/A	R	L	R		
	Submit Final Systems Manuals	R	A	N/A	O	L	R		

*Note: (Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond what the sample identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the scope, size, and complexity of the project, the degree of rigor required, and with consideration of available District resources and expertise.*

*\*For D-B-B acquisition, DOR participation or review for tasks indicated as optional for the DOR should be determined on a case-by-case basis with consideration of scope and complexity of the project/system, availability of resources, and potential benefit of DOR participation/review; these additional services require funding consideration.*

Post Occupancy Phase (D-B-B & D-B)		CxG= Gov't Comm Specialist COR = Contracting Officer Rep CxD = Design Comm Specialist DOR = Designer of Record CxC = Construction Comm Specialist O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional N/A = Not Applicable		
Commissioning Roles & Responsibilities									
Category	Task Description	CxG	COR	CxD	DOR	CxC	O&M	Notes	
Document Reviews*	Systems Monitoring Trended Data	R	R	N/A	R	L	P		
	Systems Manuals Update	R	A	N/A	O	L	R		
Site Observations*	Periodic Warranty (4 & 9 Month) Site Visits	P	P	N/A	O	P	P		
Functional Test Protocols*	Deferred and/or seasonal Testing	P	A	N/A	O	L	P		
Technical Activities*	Commissioning/Issues Resolution/Lessons Learned Meetings	P	P	N/A	O	L	P		
	Post-Occupancy Warranty Checkup and review of Significant Outstanding Issues	P	P	N/A	O	L	P		
Reports and Logs*	Final Commissioning Report Amendment	R	A	N/A	R	L	R		
	Issues Logs Closure Report	R	R	N/A	O	L	R		

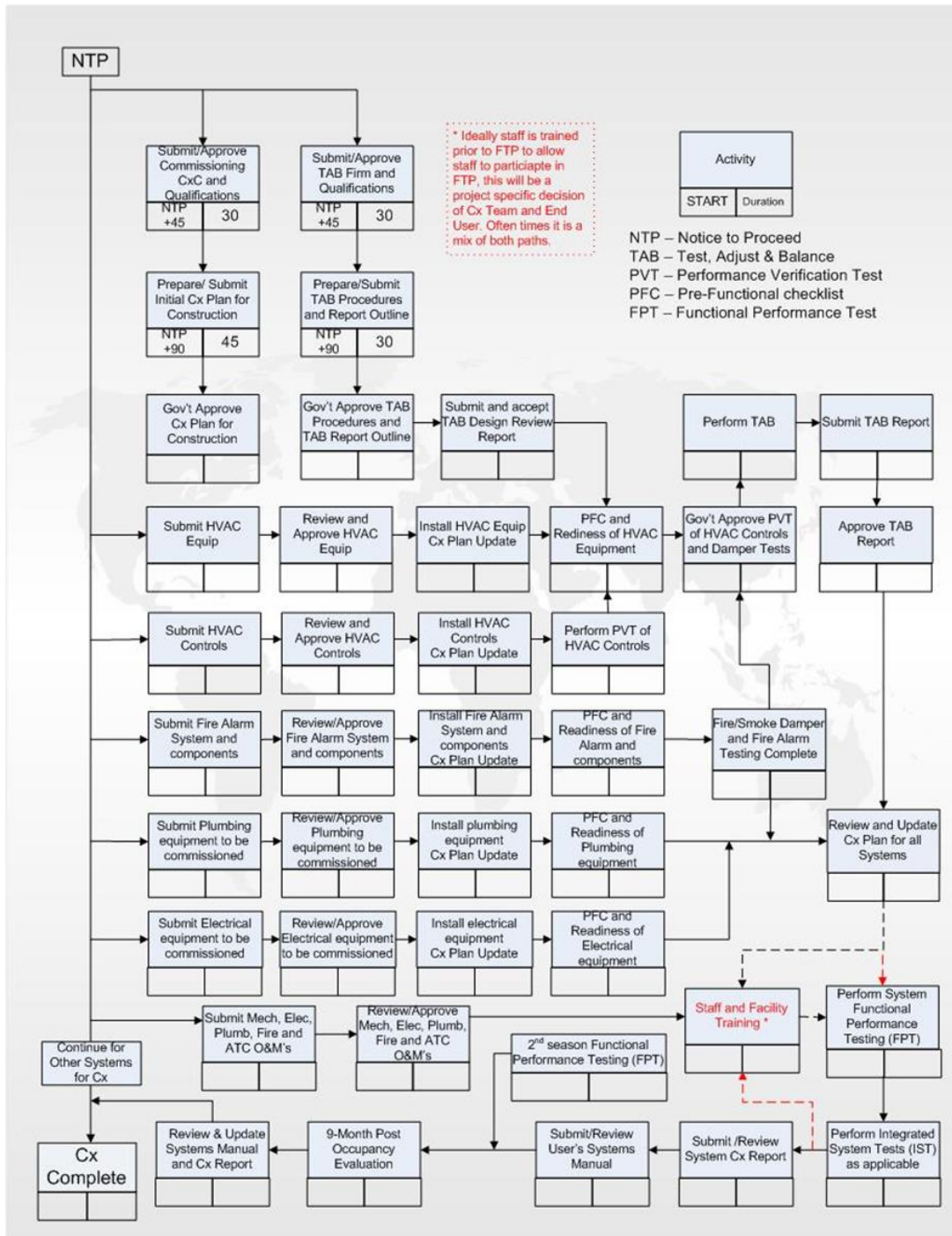
*Note: (Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond what the sample identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the scope, size, and complexity of the project, the degree of rigor required, and with consideration of available District resources and expertise.*

*\*For D-B-B acquisition, DOR participation or review for tasks indicated as optional for the DOR should be determined on a case-by-case basis with consideration of scope and complexity of the project/system, availability of resources, and potential benefit of DOR participation/review; these additional services require funding consideration.*

APPENDIX D

CONSTRUCTION COMMISSIONING ACTIVITIES FLOWCHART

*Note: (Appendix D) is just a sample to illustrate construction commissioning activities as a process. There are many more commissioning tasks to be identified beyond what the example identifies. The activities shown are graphical only and activity schedule logic would need to be developed and incorporated into the overall integrated master schedule for the project dictated by the scope, size, complexity, and the degree of rigor required.*



THIS PAGE INTENTIONALLY LEFT BLANK