

# US Army Corps of Engineers: Improving HVAC System Commissioning Specifications to be More Efficient

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## Abstract

The objective of this research is to help improve US Army Corps of Engineers (USACE) HVAC system commissioning specifications to be more efficient. Depending on who is asked, many say commissioning is a struggle for the USACE or some may say it is not. In the research process we will look at the engineering regulations ER 1110-345-723 and specifications UFGS 01 91 00.15 20 and how it is used by USACE. The questions in this research paper are: does USACE struggle with commissioning in general, and does USACE struggle with commissioning HVAC systems and does it stem from the specifications? Eight individuals throughout USACE were sent the list of questions then interviewed. From the interview process we can find some answers to the questions. The hope is to determine if USACE struggles with commissioning of HVAC is from the specifications or if the struggle is from other factors and using that information to help improve on USACE's commissioning of HVAC. The results, all those interviewed agreed that the struggle with commissioning was not with the specifications but with other factors. The questions sparked discussions on why it seems USACE struggles with commissioning from needing involvement of the commissioning team to the complexity of the systems.

## Keywords

HVAC, Commissioning, USACE, ER 1110-345-723, UFGS 01 91 00.15 20

## 1. Introduction

The US Army Corps of Engineers (USACE) is responsible for design and/or construction of all Military Construction Army (MCA) and projects in support of others (i.e., other military services and Department of Defense (DOD), Federal agencies, and vertical construction for USACE civil works projects) in the Continental United States and Outside the Continental United States (CONUS/ OCONUS). USACE involvement in a project is from initial design to final construction and turn over to the customer. This includes commissioning on all projects. USACE reviews and approves all submittals and test reports for commissioning and witnesses all the testing required during commissioning. Commissioning is always a topic of discussion not only in the Walla Walla District but throughout the districts within USACE. Some of this discussion pertains to the commissioning of Heating, Ventilation, and Air-Conditioning (HVAC) systems. Depending on who you talk to there are various opinions on if the commissioning of the HVAC systems is completed correctly or if they are not. USACE goal for design is for the project to last for many years. Commissioning is an important part of a successful project for USACE when commissioning is done right, there is a confidence that a project is being handed over to a customer on a correct path for maintaining that project for years to come. But with changing of industry, that goal is becoming harder to maintain. Commissioning is one-way USACE can help make sure that goal is achieved. In order to achieve this goal, it starts with having the right specifications for commissioning and to do this the Project Delivery Team (PDT) needs to discuss commissioning earlier in the design process.

## 2. Research Objective, Background and Methodology

## 2.1 Research Objective

The objective of this research paper is to help improve USACE's HVAC system commissioning specifications to be more efficient. In order to help improve efficiency of the specifications one needs to know how the specifications are put together. What policies and guidelines are there for USACE to follow for commissioning HVAC? What format is used for the specifications? When we understand the specification, we can determine if the struggle with commissioning HVAC is based off the specification or if there are other driving factors. If USACE is struggling because of the specifications, why? Does it lay with policies and guidelines? Does it lay with the standards in the specifications?

Answering these questions, we can provide some insight on the struggles with commissioning HVAC and help improve on USACE's HVAC system commissioning specifications to be more efficient. In effect helping USACE in becoming a stronger and efficient Agency when commissioning HVAC.

## 2.2 Background

What is commissioning: "Commissioning is the process of verifying that a building's heating, ventilation, and air conditioning (HVAC) and lighting systems perform correctly and efficiently and according to the design intent and owner's project requirements defined by the Department of Energy's 2011 Guide to Building Commissioning" (Baechler, 2011). How does this affect USACE? As mentioned above USACE is responsible for all MCA and support construction projects and that includes commissioning.

In February 2015, an Engineering and Construction Bulletin (ECB) came out that establishes the requirements for and provides information and guidance on Total Building Commissioning Processes on Army projects for Engineers, Project Managers and Construction Managers (ECB 2015-6). It reviewed the current ER 1110-345-723, Systems Commissioning Procedures and identified four tasks as new or needed augmented.

1. NEW: the designation of a USACE Commissioning Authority and supporting Commissioning team in the predesign/design phase
2. AUGMENT: design review process to include a commissioning review.
3. AUGMENT: the construction submittal review process by including the Commissioning Authority (or designated member of Commissioning team) review for systems being commissioned
4. AUGMENT: the warranty inspection with a Post Occupancy inspection by the commissioning team.

USACE, as the designated Commissioning Authority (CxA), is to provide oversight assurance of the entire commissioning process (ER 1110-345-723, 31 Mar 17).

USACE uses Engineering Regulations (ER) to develop the design for their projects. These ERs are written policies and guidance that are to be used when designing. One ER in particular is ER 1110-345-723, Systems Commissioning Procedures, dated 31 July 1995 (ER 1110-345-723, Systems Commissioning Procedures, 1995). The primary focus of ER 1110-345-723 was limited to commissioning of facility HVAC Controls (ER 1110-345-723, 31 Mar 17). In March 2017, ER 1110-345-723 was revised to total building commissioning procedures. This updated 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 (ER 1110-345-723, 31 Mar 17). This was to capture all the commissioning activities through the life of the project, so the systems operated per owners' requirements and per the construction contract plans and specifications.

This brings in the specifications. USACE's specifications are derived from the Unified Facilities Criteria Program (UFCs) and the Unified Facilities Guide specifications (UFGS). The UFGS pertains to planning, design, construction, and operation and maintenance of real property facilities (WBDG, 2021). The Unified Facilities Criteria Program is to unify all technical criteria (WBDG, 2021). The UFGS covers several design processes such as Design-Build and Design-Bid-Build. Each USACE district handles projects and contracts differently depending on the scope of work, complexity, and in-house expertise. It also depends on if it is military construction or civil works. Military construction is predominantly Design-build whereas Design-Bid-Build is predominantly civil works. The UFGS

format has three sections: general, product, and execution. Depending on the design of the project will depend on what sections are used.

The UFGS is the general specification for the contracts and the starting point. The specifications are what the work is to be done and, in this case, what commissioning is to be accomplished. There are three specifications to look at in the UFGC, Section 01 91 00.15 20 Total Building Commissioning, Section 23 05 93 Testing, Adjusting, and Balancing for HVAC, and Section 23 08 00.00 20 Commissioning of Mechanical (and Plumbing) Systems. These three general specifications are the starting point of the design and are tailored to the scope of work to be performed for each project. They pull in all the required standards needed for specific sections and the testing. Specification sections 23 05 93 and 23 08 00.00 20 deals with testing the equipment for HVAC and all the other equipment individually. Section 01 91 00.15 20 deals with testing all the equipment as a system.

## **2.3 Research Methodology**

This research paper utilized the interview method to understand the USACE specifications for commissioning of HVAC. The specification this research paper will focus on is UFGS 01 91 00.15 20 for both Design-build and Design-Bid-Build. The plan is to interview nine individuals throughout USACE and get their thoughts for commissioning of HVAC, from initial design, specifications, construction and commissioning. By using the interview process, one should learn what Engineering Regulations (ERs) are being used and how ER's are used to draft the specifications for the commissioning of the HVAC system by means of UFGS 01 91 00.15 20. The interview process will be used to understand how specifications are used for the commissioning and what requirements are there for commissioning. During the interview process following three questions will be asked:

1. Does USACE struggle with commissioning in general?
2. Does USACE struggle with commissioning HVAC systems?
3. Does it stem from the specifications?

By gathering the answers from the interviewees, it should be determined if the struggle is from the specifications. The follow-on questions will be based off how the interview responded to the previous question. These questions are:

1. Why do you think that USACE struggles with in commissioning of HVAC systems: lack of experience, inefficient specifications, or both?
2. What do you think USACE can do to improve the process?
3. What does your district have in their specifications for commissioning HVAC systems? What specific standards are called out for commissioning?
4. Do you think if we improve on USACE specifications, it will improve on our commissioning?

If during the interviews, it is found that USACE does not struggle with commissioning of HVAC or does not struggle because of the specifications based of the question: "does USACE struggle with commissioning HVAC and does it stem from the specifications?" The follow-on questions will be based off how the interview responded to the previous question. The follow-on questions are:

1. What is being done right in your district? Is it something that can be used USACE wide?
2. Is there a specification section that could be improved on?
3. What does your district have in their specifications for commissioning HVAC systems? What specific standards are called out for commissioning?
4. Do you think the specifications have helped with commissioning HVAC systems?

From the results of the interviews, it shall be determined if USACE is struggling with commissioning HVAC systems and if it is or is not because of the specifications.

## **3. Results**

This research paper interviewed eight individuals throughout USACE: Baltimore District, Hydroelectric Design Center (HDC) Mobile, Portland District, Walla Walla District, and Far East District – Korea. Five of the interviewees

work in the design branch for USACE, one interviewee works in the commissioning section branch, and three interviewees work in construction branch. All the interviewees were asked the same three initial questions:

1. Does USACE struggle with commissioning in general?
2. Does USACE struggle with commissioning HVAC systems?
3. Does the struggle stem from the specifications?

There were varying responses to “Does USACE struggle with commissioning in general and does USACE struggle with commissioning HVAC systems?” Some saying yes that USACE struggles with commissioning and with commissioning of HVAC systems. While some responding that no USACE does not struggle with commissioning in general or with commissioning of HVAC systems. But all of them seemed to agree the struggle or not with commissioning was that it was not from the specifications or the standard that are referenced in the specifications.

When the specifications followed the ER 1110-345-723, Total Building Commissioning Procedures, commissioning of the HVAC system would be successful. 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 (ER 1110-345-723, 31 Mar 17). The exception is with buildings that are 5,000 GSF or less, then the use of ASHRAE 189.1, section Building Acceptance Testing, is sufficient. The Total Building Commissioning (TBCx) guidance is to involve Commissioning Authority (CxA) and the commissioning team early in the design process and keeping them involved through design, into and through construction. The CxA in this case is USACE and has the overall oversight but can assign responsibilities to other individuals. Reference Appendix A (ER 1110-345-723, 31 Mar 17).

The ER 1110-345-723 also explains the role of Commissioning Specialist for the Government (CxG), and Commissioning Specialist for the Design Phase (CxD), and Commissioning Specialist for the Construction Phase (CxC). It was brought up that it was key to have CxG and CxC. The CxG is the lead individual, employed by the Design and Construction Agent (USACE), but not affiliated with the construction contractor, and is responsible for government oversight of the commissioning process (ER 1110-345-723, 31 Mar 17). 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 and shall be employed by a commissioning firm that is a first-tier subcontractor hired by the construction contractor (ER 1110-345-723, 31 Mar 17). It was mentioned that CxG and CxC are not always assigned to projects for various reasons. The CxG may not be assigned to a project as some districts or area offices may not have a designated commissioning individual or section. In this case the lead engineer is to be assigned to assist in commissioning and in some cases, it is left to the onsite government Quality Assurance Representative (QAR) to be present for commissioning. In some cases, the commissioning firm is not always specified in the specifications. Then the CxC usually is the installer of the equipment that is leading commissioning instead of an individual of commissioning firm. Those interviewed all said having these individuals identified and involved early in the project would help in having a successful commissioning, though funding may play into what is specified for some districts.

The early involvement of the commissioning team was the key for most interviewed as it gets everyone talking about commissioning and what will be needed to commission not just the HVAC but the system. The specification section UFGS 01 91 00.15 20 Total Building Commissioning is the starting block for laying out how USACE wants to see from the contractor when commissioning. Even though most of the interviewees indicated that earlier involvement of the commissioning team was a key, it was mentioned that having the full team involved is not always the case. Most cases the full team was involved earlier in the design but was not always involved in the construction phase. This seemed to be common for the districts that do not have a commissioning section branch and rely on their design engineers to be part of the commissioning team. Some interviewees had indicated they were the commissioning team. Many said listing the team and their roles during that early involvement is key, that there were times that they were not sure who was on the team and had what role and what their responsibility was. Keeping them engaged through the who process was a challenge as everyone may have several different projects going on and at different stages. Many times, once the project hit the construction phase involvement dropped off dramatically or was nonexistent. Some did mention that funding and schedule played a role in involvement. Some projects didn't have the funding for continuous involvement and had to watch the number of hours being charged. Most of the time leaving little time to be present for commissioning. Those that have experienced a commissioning team that was involved, commissioning of the HVAC was successful and commissioning in general was successful.

The UFGS 01 91 00.15 20 has two sections: general and execution. The product section is left blank in this specification. The general section lays out all the general requirements for communicating, the systems to be commissioned, and the commissioning team. This section specifies the details in what to include in a project schedule and the required submittals USACE wants to approve. The section covers the first-tier subcontractor, the commissioning firm, and the required specialist as mentioned in the ER 1110-345-723. The commissioning standards are also listed in this section. If the government is planning to use a third party for commissioning, it will be called out in this section as well. The section ends with the requirement for certificate of readiness. The certificated of readiness states “Prior to scheduling Functional Performance Tests, the Quality Control Manager must issue a Certificate of Readiness for each system, certifying that pre-functional checks have been completed, open issues have been resolved, and the system is ready for Functional Performance Testing” (UFGS 01 91 00.15 20, February 2021). This section covered one or more topics brought up by interviewee of items needed to have a successful commissioning. The key take-aways from the interviews, communication and certificate of readiness. Communication was mentioned in one way or another during the interviews and communicating through all phases of the project from design, constructions, and into commissioning. Some interviewees did say with commissioning very little to nothing was communicated on commissioning until the project was about ready or ready to commission. The reason why this was: everyone is focused on the construction of the project and making the contract completion date that commissioning is an afterthought. Another topic mentioned was the certificate of readiness. A requirement that is often missed or only partially completed. If completed or provided it is usually missing the results or documentation that shows that the systems were tested and are ready for startup. Again, the reason why this was: everyone is focused on the construction of the project and making the contract completion date that commissioning is an afterthought. The contractors are so focused on the construction that they fail to read the requirements for commissioning.

The execution part of the UFGS 01 91 00.15 20 should help the general section as it describes the work to be accomplished during the commissioning process. This section lays out requirement for design commissioning coordination meeting (requirement for Design-Build), design phase commissioning plan, the design review, construction submittal, commissioning kickoff meeting, and regular commissioning coordination meetings. This section covers the construction phase commissioning plan and all the checklists that are required for the plan:

1. Template Building Envelope Inspection Checklists
2. Pre-Functional Checklists
3. Functional Performance Test Checklists
4. Integrated Systems Test Checklists
5. Building Envelope Inspection and Testing

All of which are required to be submitted with the certificate of readiness. The pre-functional checklist has its own paragraph that explains in detail what to check and who is to witness it. It even calls out to provide manufacturer start-up checklists associated with equipment with the submission of the Pre-Functional Checklists (UFGS 01 91 00.15 20, February 2021). There are sections for functional performance and integrated systems tests and a training plan. An important part of this section is Commissioning Report section. This section details what the contractor shall include in the commissioning report. The report shall include an executive summary, a list of any deficiencies discovered during commissioning and the corrective means for the deficiencies, and a completed copy of all the checklists, commissioning plans, training attendance rosters, design review reports, submittal review reports, and the approved Testing and Balancing (TAB) Reports. The execution part of the UFGS 01 91 00.15 20 is very detailed in its general form and should only get better when tailored to the specific project. The key take-aways from the interviews: the checklists and coordination meetings. The ER 1110-345-723 guidance was for the commissioning team’s involvement throughout the project from initial design through construction. The UFGS 01 91 00.15 20 does that with coordination meetings. For Design-Build, the first meeting detailed is the design commissioning coordination meeting. “The purpose of the meeting is to discuss the commissioning process, including project contract requirements, lines of communication, roles and responsibilities, schedules, and documentation requirements (UFGS 01 91 00.15 20, February 2021). The specification requires for there to be two meeting held for the design, one is at 35 percent and one at 50 percent of the design. A follow-on meeting for Design-Build is the design phase commissioning plan. This plan is to “Outline the commissioning process, commissioning team members and responsibilities, lines of communication, and documentation requirements for the design phase of the project in the

Design Phase Commissioning Plan. Identify the Commissioning Standard chosen for the project (UFGS 01 91 00.15 20, February 2021).

The design review meeting is to be held once the contract is awarded. “The design review must include verifying the Design Plans and Specifications for the systems to be commissioned are prepared in accordance with the contract documents” (UFGS 01 91 00.15 20, February 2021). The commissioning kickoff meeting is to discuss the commissioning process for the specific contract. The discussion should include the contract requirements, lines of communication, roles and responsibilities, schedules, documentation requirements, inspection and test procedures, and logistics needed to complete the commissioning. This meeting is to be held early in the project normally some many days after the notice to proceed. For some districts this meeting is help so many days before the approved scheduled commissioning date.

The UFGS 01 91 00.15 20 requires regular commissioning coordination meetings. These meetings are to be held once the installation of the HVAC equipment has begun and be scheduled to happen monthly. This section requires bi-weekly meeting when the commissioning is with 30 days of the scheduled commissioning. The purpose of this meeting is to give the government commissioning team a status of the system to be commissioned, any issues, submittal status, and if any commissioning activities are coming up. The regular commissioning meeting was a topic of discussion during the interview process. The interviewee had some reserve if theses meeting were happening from some of the commissioning they had witnessed. The regular commissioning coordination meetings as drafted in the UFGS does not require the contractor to take or submit meeting minutes as it is required for other meetings called out in the specifications. It was mentioned that it would be nice to have the requirement for the contractor to submit the meeting minutes of the regular commissioning coordination meetings. In some cases, some districts have in their specification that the meeting minutes are to be attached to the contractor daily reports and to be uploaded into the Resident Management System (RMS). RMS is a quality management and contract administration program designed by Resident Engineers of USACE. But the UFGS does not require the contractor to submit the regular commissioning coordination meeting minutes as attachments to their daily reports. The interviewee that it would be going to have language in the specifications to document the regular commissioning coordination meeting and have it as a submittal or attached to the daily reports. This seems like an easy fix and one that can be addressed during the initial design phase. During the initial design phase, the commissioning team should be able to request the meeting minutes for the regular commissioning coordination meeting be recorded and then either be a required submittal or as an attachment to the contractor’s daily reports. But remember earlier in the report the commissioning team could just be one individual reviewing the commissioning section and may have specific things they are looking for and meeting minutes may not be one of them. Requiring the meeting minutes to be recorded and submitted either as a submittal or attached to the daily reports as mentioned earlier, helped with the keeping individuals engaged and possibly raise questions even though they were not present for the meeting.

UFGS 01 91 00.15 20 listed a couple of commissioning plans and commissioning checklists. The design phase commissioning plan has two parts, the interim and the final. The interim commissioning plan should “identify the commissioning and testing standards and outline 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, and Template Building Envelope Inspection Checklists” (UFGS 01 91 00.15 20, February 2021). The final commissioning plan should the approved interim plan plus “the Pre-Functional Checklists, Integrated Systems Test Checklists, and Functional Performance Test Checklists for each building, for each system required to be commissioned, and for each component for inclusion in the Final Construction Phase Commissioning Plan” (UFGS 01 91 00.15 20, February 2021). The commissioning plan should be planned with seasons in mind as there could be requirements for testing for cooling and heating for the building.

As stated above, there are several checklists required to be completed. During the interviews while discussing the interview questions provided, a topic that came up was commissioning plans and checklist. As stated earlier, all the interviewees said the specification were not the issue for USACE struggle with commissioning in general or with HVAC. But it was the fact that many contractors failed to follow the specification specially when it came to checklists and commissioning plan requirements. That the contractor did not read the requirements for commissioning and did not realize what was all required to be provided. In many cases the checklist was not provided before scheduling commissioning. The commissioning plan in some cases was not provided for review until few days before the commissioning. Earlier involvement of the commissioning team doesn’t mean that the contractor will follow the specification. More times than not USACE is left rushing to complete reviews of checklist and commissioning plans

or left to start commissioning with partial checklists or commissioning plans still under review. Which many time results in rescheduling the commissioning because what the contractor said was completed on the checklist is now not working or was not tested to begin with.

Some of the interviewees said they had completed checklists and approved plans but when it comes to commissioning the contractor failed to have the individual assigned to commission the system onsite. The contractor had thought USACE would be doing the commissioning not just witnessing it. Which resulted in delaying or rescheduling the commissioning due to little or no communications. Some of these issues were addressed by some districts by having the third-party commissioning agent. But not all districts plan for that and in these cases USACE must be more diligent and involved not just in the earlier design but through construction by keeping track of when requirements due be present for the pre functional checklist activities.

Another topic of discussion when interviewing that came up was the commissioning reports. In most cases it was getting the contractor to submit them for USACE to review. The contractor would go through the checklists as required by UFGS 01 91 00.15 20, but the contractor would not record the results or if they did record the results only recorded certain results or just fail to submit the results. The UFGS requires an initial commissioning report and a final commissioning report. The initial report is just the commissioning team's validation of the Functional Performance Tests and Integrated Systems Tests. The final commissioning report is much more involved as stated previously. In many cases the reports submitted are incomplete and are returned unapproved. A failure of the contractor to read the specifications which from everyone interviewed if they followed the specifications, it clearly identifies what is required on the commissioning report.

Even though all the individuals interviewed agreed the specifications were not the reason that is seems USACE struggles with commission, the questions asked can USACE improve on the specifications, and would this help improve USACE's commissioning? Besides the requiring of the commissioning meeting minutes to be recorded.

There was one during the interview that mentioned that providing good examples of what USACE is looking for, has helped with commissioning. This went for the pre-functional testing, functional performance test checklists, integrated systems test checklists, and building envelope inspection and testing. Then the contractor had something to follow when they put their checklist together as required by the contract. Other than the two suggestions list above none of the other interviewee had any to add that if the specifications are followed commissioning should be successful.

There were a few that mentioned the complexity of the system being commissioned being a reason for the struggle. The ER 1110-345-723 was updated to commission the entire building system. One cannot just test the HVAC system on its own. That the HVAC is just one but of an entire system. Depending on the building there could be just a single unit to test were just doing the Testing and Balancing (TAB) and submitting that report would be acceptable to testing multiple units where all the pre-commissioning checklists need to be completed before commissioning of the system can being. The system could include (USACE sustainability, 2013 April 3).

1. HVAC
2. Building envelope
3. Protection systems as in Fire suppression or lighting protection
4. Plumbing
5. Electrical System as in power or lighting
6. Communication systems
7. Alarms

The systems today are all digital and require Programmable Logic Controller (PLC) run the system. Even when you have completed all the checklists, commissioning the system may indicate one or more subsystems may need adjusting and may require adjusting several times to balance the system and complete commissioning.

During the interviews it was mentioned that sometimes the design for projects seems to be excessive. A safety factor is usually built into the design but through the design process that safety factor is compounded to a point the equipment that is install is much larger than needed for the buildings and USACE designs usually have redundancies built in so now there is two pieces of equipment larger than needed that need to be commissioned. The example explain during the interview was with chillers. There were two chillers installed for a building that's full capacity may have used

just 25% of the chillers capacity and the building had two of these chillers. Commissioning now has an added challenge as in some commissioning plans the equipment must be commissioned at 100% of its capacity which if the whole building only uses 25% now the commissioning plan must include a means of commissioning the equipment at 100% capacity. Subsequent paragraphs, however, are indented (here insert the second paragraph).

## 5. Conclusions

Commissioning extends through all phases of new or major renovation projects, from predesign to Owner occupancy and operation, with tasks during each phase to ensure verification of design, construction, and operator training (ASHRAE Guideline 0-2019).

This study discovered that the specifications is not the reason USACE seems to struggle with commissioning of HVAC or in general. There are many other factors one must look at when commissioning. How involved was the commissioning team assigned to the project, were their roles and responsibilities set was a major factor for a successful commissioning. Making sure regular commissioning coordination meetings are taking place and the meeting minutes are being documented. Include examples, when possible, for all the checklists that are required before commissioning. Following up with the contractor to make sure they are completing the checklists and are submitting them for review. Follow up with the commissioning team to make sure they are reviewing the submittals from the contractor and are providing their feedback. Doing as many of these things as possible will help making the commissioning HVAC a success.

## Appendix A

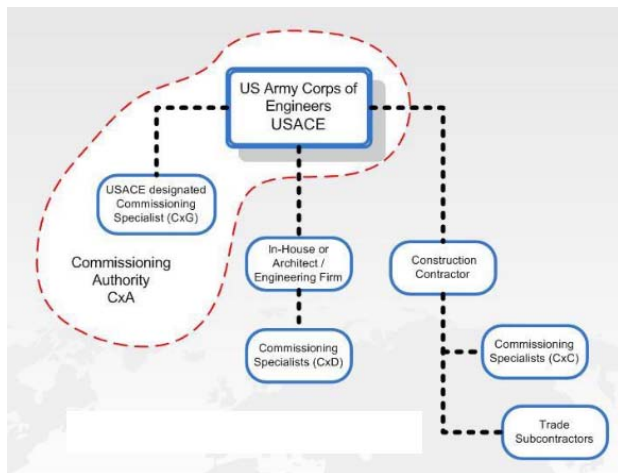


Figure 1. Design-Bid-Build (D-B-B) Commissioning Organization Chart (ER 1110-345-723, 31 Mar 17)

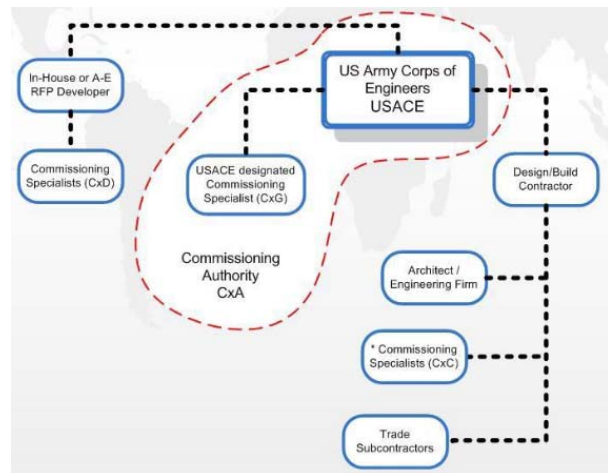


Figure 2. Design – Build (D-B) Commissioning Organization Chart (ER 1110-345-723, 31 Mar 17)

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