Depth Research: Commissioning Vs. Retro-Commissioning

A. Executive Summary

The industry research performed in this section focuses on the differences in the processes for commissioning of new construction and retro-commissioning of existing building equipment.

In the first part of this section a survey was developed in order to be distributed to industry personnel including owners, architects, contractors, and commissioning agents. The goal of the survey was to obtain the opinion of industry personnel on the use of commissioning and retro-commissioning processes.

The second part of this section contains the summary of the survey responses from the previous section along with interviews conducted with industry contacts. Responses depended on the persons experience with commissioning. The general opinions of those contacted were owner's cost savings on operation and maintenance of building systems, the contractor's reduction in call backs for warranty and comfort issues, and commissioning agents stress on the early introduction of the commissioning processes on a project.

Research of industry papers was conducted in the third section in order to obtain more information on the differences in the steps of the commissioning of new construction and retro-commissioning of existing building equipment. The commissioning process is broken down into five steps and the retro-commissioning process is broken down into four steps which are detailed in this section.

The summary and recommendation section includes a summary of the research conducted in this section along with recommendations for the use of commissioning processes and how this research related to the focus project for this report.

B. Overview

The commissioning of fit-out projects in existing facilities and retro-commissioning of existing facilities is the focus of the research conducted in this section. Commissioning of fit-out projects follow much the same process of that of new construction in that many of the same steps are followed; however the retro-commissioning process used to commission existing facilities that were originally constructed without the use of the commissioning process follow somewhat different steps. The processes of each of these styles of commissioning will be discussed in this section. The steps used to complete this research include:

1. Development of a survey to obtain the opinions of industry personnel on commissioning.
2. Compile information from this survey.
3. Research published material on commissioning and retro-commissioning.
4. Summarize research information to develop commissioning use recommendations for what types of projects would benefit the most from the commissioning and retro-commissioning processes.
5. Bibliography of sources utilized throughout research for this section.

C. Survey

My name is Devin C. Learn; I am an Architectural Engineering, Construction Management Option Student at Pennsylvania State University. I am conducting research on the commissioning process for construction, specifically looking at Healthcare construction. Below is a short word document survey developed to access the pros and cons of commissioning in projects within a healthcare facility. This survey is being released to Mechanical Contractors, Owners, General Contractors and Independent Commissioning Agencies. Your response will be compiled into a decision matrix to determine what type of projects will benefit the most from commissioning applications. Responses will be confidential and used solely for the academic purposes of my senior thesis research. Form of response can be hand written or typed scanned and emailed to dcl146@psu.edu or mailed to Devin C. Learn, 338 Reynolds Ave. Bellefonte, PA 16823. Results will be compiled and analyzed in mid March. Your response is greatly appreciated.

Sincerely
Devin C. Learn
Pennsylvania State University
Architectural Engineering
Construction Management

1. Your Name:
2. Current Company:
3. Role in Company:
4. Have you ever been involved in the commissioning process?
5. If so what type of projects were they used in?
6. How do you feel commissioning affected the outcome of the project?
7. What do you feel could have been done differently in respect to the commissioning process?
8. Have any of the projects that you have worked on or have knowledge utilized the commissioning process in an existing facility such as a hospital were previous projects did not utilize the commissioning process?

9. If so how do you feel commissioning affected the outcome of these projects versus projects involving new construction of facilities?
10. In your opinion what are some of the pros of utilizing commissioning?
11. In your opinion what are some of the cons of utilizing commissioning?
12. Do you feel that current and future project within existing facilities would benefit from the implementation of commissioning?
13. What issues do you think effect the decision to utilize commissioning?
14. Who do think should be involved in the decision process to decide to what extent commissioning should be implemented in a project?

D. Survey Results

Due to limited response to the actual survey most of the information obtained for this section comes from personal conversations with industry contacts. While not the planned method for compiling information a broad spectrum of opinions was still acquired for the purposes of this research. The summary of information in this section has been broken down into three sources owners, contractors, and commissioning agents.

Owners-

An owner's opinion on commissioning depends greatly on their experience and knowledge of the commissioning process. Owners that have limited experience with commissioning often have unrealistic expectations when someone comes to them and says that they can save them money on life-cycle costs of their building. Once an owner understands the commissioning process and begin to comprehend its benefits they can more easily weight the decision on whether or not it fits into their goals and financial plan. Type of facility can affect the benefits of commissioning, specifically whether or not the facility has its own maintenance staff such as a university or healthcare facility or if they outsource their maintenance.

The intended use of a building also plays heavily on an owner's willingness to consider implementing the commissioning process. For owners such as developers the commissioning process may be less desirable because it comes with a higher initial cost of which they will not own the building long enough to benefit from the life-cycle cost savings. However, depending on the final use of the building being constructed by a developer they may choose to utilize the commissioning process and use it as a marketing tool in obtaining tenants. A building that will be used for labs or healthcare facilities tend to benefit more from the commissioning process due to the complexity of the systems used and there requirements.

Commissioning when implemented successfully is a definite advantage over the long term and is a sound investment. The major benefits are reduced operation and maintenance costs, less comfort complaints from tenants, and incentives.

Contractors-

Contractors have mixed feelings about commissioning due to some of the impacts that it has on a project. As with owners some of these feelings come from the fear of the unknown. Contractors and subcontractors that do not have experience with commissioning fear that having another outside consultant looking over their shoulder will interfere with their construction methods and stretch out schedules that are often very limited on extra time. Even though having a commissioning professional within the contractor's own company is an option most fear that the additional cost of having someone dedicated to just commissioning services will not be utilized enough to offset the cost, as they may not always have projects under construction that are utilizing commissioning. This may change in the future as more projects begin to use the commissioning process to some extent but until that happens this may not be a feasible option for many companies.

Contractors that do have experience with commissioning are starting to see some of the benefits of the process. These benefits include higher owner satisfaction rates and reduced expenses with fewer call backs for warranty work. All contractors represented in this research utilized outside commissioning consultants but verified that as commissioning becomes more widespread hiring a commissioning professional at their company will become a more feasible option.

Commissioning Agents-

Commissioning agents have seen a steady increase in the use of commissioning processes in construction over the past few years as more owners are starting to realize the long term benefits. With the increase in the use of commissioning repeat clients are starting to involve the commissioning agents earlier on in the design and pre-design planning phases. This is one of the things that commissioning agents stress as an important issue in helping to reduce

commissioning costs as a whole on a project due to the reduction in design rework. If the use of commissioning on a project is identified early on then the commissioning agent can be involved in the initial design which has been found to make the process more efficient.

E. Research

The intent of the commissioning vs. retro-commissioning research is to compare and contrast the process for commissioning of new construction and the retro-commissioning of facilities that were originally constructed without the use of the commissioning process. The information contained in this section comes from various published documents of the commissioning and retro-commissioning processes. The intent of the research performed is to formulate a decision matrix for what types of projects would benefit the most from each of these types of commissioning processes. The summary and decision matrix developed from this research will be presented in part 4 of this section under research summary.

a. Introduction to Commissioning/Retro-Commissioning-

Building commissioning is a method of risk reduction for new construction projects. Commissioning activities for new construction follow the construction process from pre-design through construction and acceptance. ASHRAE Guideline 1-1996 defines commissioning as the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.

Retro-commissioning a term used to define existing building commissioning, is an event in the life of a building that applies a systematic investigation process for improving and optimizing a building's operations and maintenance. Retro-commissioning occurs after construction, as an independent process that usually focuses on energy using equipment such as mechanical equipment, lighting, and related controls. Depending on the needs of the owner it may or may not emphasize bringing the building back to its original intended design. This also depends on whether the original design documentation exists or is still relevant. Retro-commissioning is applied to buildings that have not previously been commissioned to ensure system functionality. Depending on the current needs of the owner, the budget, and the condition of the equipment the retro-commissioning process most often focuses on the dynamic energy using systems

with the goal of reducing energy waste, obtaining energy cost savings, and identifying and fixing existing problems.

In general commissioning and retro-commissioning are used to ensure that the building meets the owner's needs in terms of functionality of systems that ensure occupant comfort, energy use, and operation and maintenance costs. Regardless of what type of commissioning is applied the extent to which it is applied depends on several variables such as complexity of building systems, type of facility, and intended use.

b. Process Steps-

Since the final outcome of any form of commissioning is to obtain a building with efficient system operation, the biggest difference between commissioning of new construction and retro-commissioning of existing buildings are the steps performed in the process. The steps for these two different forms of commissioning will be detailed below. It is important to remember that these are basic guidelines as some steps may vary depending on specific project requirements.

Commissioning of New Buildings:

Commissioning of new construction projects is broken down into 5 steps conception or pre-design phase, design phase, construction/installation phase, acceptance phase, and post-acceptance phase.

Step 1- The first step conception or pre-design phase is not always performed during the pre-design phase of the project but it is in the opinion of industry professionals that if at all possible the decision to commission a building should be made early so that this step can be performed early to reduce rework and additional cost of redesign. Early involvement of commissioning professionals also aids in selection of a design team that is experienced in the commissioning process which will help ensure a successful project. Items to be completed in the first step of the commissioning process for new construction include the development of commissioning objectives for the project, hiring of

commissioning provider, development of design phase commissioning requirements and selection of the design team.

Step 2- The second step is the design phase of the commissioning process. This step is important to receiving accurate bid information from contractors and subcontractors because specifications for bid documents are developed. If this step is not completed before the project goes out for bid the budget developed will not be accurate, therefore acquiring realistic project budget information for funding will not be possible. Another important reason for the development of specifications is so the contractors preparing a bid can identify equipment that will have long lead times so they can be ordered immediately after awarding of the project. Items to be completed in this step of the process include a commissioning review of the design intent, writing the commissioning specifications for bid documents, awarding of job to contractor, and development of commissioning plan.

Step 3- The construction/installation phase is a phase in which design, commissioning, and contractor personnel will be required to work closely together to ensure that all specifications are being met as far as procurement of equipment and installation procedures. For this reason it is important to maintain a free flow of information between the team members from all of these areas as well as hold meetings in which all teams are represented. Items to be completed in the construction/installation phase include gathering and reviewing documentation, holding commissioning scoping meetings and finalize plan, development of pre-test checklists, and start up equipment or perform pre-test checklists to ensure readiness for functional testing during acceptance.

Step 4- The acceptance phase includes executing functional tests and diagnostics, fixing deficiencies, retesting and monitoring as needed, verifying operator training, review of operation and maintenance manuals, and building/retrofit acceptance by owner. This phase is intended to verify that all steps leading up to this point have been completed in an acceptable manor and that all equipment is functioning to design specifications.

Step 5- The post-acceptance phase includes preparing and submittal of final report, performing deferred tests (if needed), and development of re-commissioning plan/schedule. At this point substantial completion of the project has been reached and the goal now is to develop a plan to periodically verify that the systems are still operating efficiently.

Retro-Commissioning of Existing Building Equipment:

Retro-commissioning of existing building equipment is broken down into 4 steps the planning phase, investigation phase, implementation phase, and project hand-off and integration phase. The biggest difference between the steps in the commissioning of new building and the retro-commissioning of existing buildings and equipment is the lack of the design phase. This occurs for an obvious reason there is already equipment in place, however this equipment must be analyzed to determine how it is functioning.

Step 1- The first step in the retro-commissioning process is the planning phase. This phase is very similar to the conception or pre-design phase in the commissioning of new building process; however, it is made more complicated due to the often incomplete documentation from the original system components. Items to be completed in this phase are development of commissioning objectives, hiring of commissioning provider, review of available documentation and obtain historical utility data, and development of the retro-commissioning plan.

Step 2- The investigation phase includes performing site assessments, obtain or develop missing documentation, develop and execute diagnostic monitoring and test plans, develop and execute functional test plans, analyze results, develop master list of deficiencies and improvements, and recommend most cost-effective improvements for implementation. During this phase the real scope of work will be developed and a realistic feasibility analysis can be performed based on the information obtained. It is difficult to assume what changes will need to be made before the actual tests of the existing equipment are performed.

Step 3- The implementation phase of the retro-commissioning process can be a complicated step depending on several variables which include accessibility of

existing equipment and how downtime of equipment will affect building tenants among others. Items to be completed during this phase include implementation of repairs and improvements, retest and re-monitor for results, fine-tune improvements if needed, and revise estimated energy savings calculations.

Step 4- The project hand-off and integration phase of the retro-commissioning of existing buildings and equipment include all the same items as the post-acceptance phase of commissioning new buildings, which are preparation and submittal of the final report, performing deferred tests (if needed), and development of re-commissioning plan/schedule. However, one difference in these two forms of commissioning is that the owner of a building that has utilized the retro-commissioning process can easily document the cost savings with the updated systems. This makes it important to review realistic savings goals early in the project to avoid negative feelings by the owner once the process has been completed.

The steps for commissioning of new construction and retro-commissioning are illustrated below in Table 2.

Table 2. New-construction commissioning vs retrocommissioning

New-construction commissioning	Retrocommissioning (existing equipment)
1. Conception or pre-design phase (a) Develop commissioning objectives (b) Hire commissioning provider (c) Develop design phase commissioning requirements (d) Choose the design team	**1. Planning phase** (a) Develop commissioning objectives (b) Hire commissioning provider (c) Review available documentation and obtain historical utility data (d) Develop retrocommissioning plan
2. Design phase (a) Commissioning review of design intent (b) Write commissioning specifications for bid documents (c) Award job to contractor (d) Develop commissioning plan	**[No design phase activities]**
3. Construction/installation phase (a) Gather and review documentation (b) Hold commissioning scoping meeting and finalize plan (c) Develop pre-test checklists (d) Start up equipment or perform pre-test checklists to ensure readiness for functional testing during acceptance	**2. Investigation phase** (a) Perform site assessment (b) Obtain or develop missing documentation (c) Develop and execute diagnostic monitoring and test plans (d) Develop and execute functional test plans (e) Analyze results (f) Develop Master List of deficiencies and improvements (g) Recommend most cost-effective improvements for implementation
4. Acceptance phase (a) Execute functional tests and diagnostics (b) Fix deficiencies (c) Retest and monitor as needed (d) Verify operator training (e) Review O&M manuals (f) Building/retrofit accepted by owner	**3. Implementation phase** (a) Implement repairs and improvements (b) Retest and remonitor for results (c) Fine-tune improvements if needed (d) Revise estimated energy savings calculations
5. Post-acceptance phase (a) Prepare and submit final report (b) Perform deferred tests (if needed) (c) Develop recommissioning plan/schedule	**4. Project hand-off and integration phase** (a) Prepare and submit final report (b) Perform deferred tests (if needed) (c) Develop recommissioning plan/schedule

(A Practical Guide for Commissioning Existing Buildings; By Tudi Haasl, Portland Energy Conservation Inc. and Terry Sharp, Oak Ridge National Laboratory)

c. Benefits and Costs-

There are many variables to the benefits and costs of commissioning and retro-commissioning many of which have to do with the needs of owner's and project specific requirements. Some key factors that can have a direct impact in developing a commissioning budget include:

- When the commissioning process starts (during design, construction, or post construction)
- The number and complexity of systems to be commissioned
- Complexity of the systems
- The level of detail required during the commissioning process (does it include documenting and witnessing all equipment start-up, verification tests, spot checking the balancing report, etc.?)
- Deliverables (design intent document, number of design reviews, commissioning plan, O&M manual review, final report, etc.)
- Allocation of costs (will the budget allow for increased design fee, increased contractor bids, training time for O&M personnel, the commissioning consultant's fee, etc.)
- Type of project (design-build, plan and spec, retrofit, etc.)

(Whole Building Design Group webpage; http://www.wbdg.org/project/plan_comm_process.php)

For this reason each project should be looked at on an individual basis. Below is a summary of average costs and standard benefits of commissioning and retro-commissioning.

Commissioning costs for new buildings average about $1 per square foot and the payback period averages 4.8 years. These costs vary widely with scope and supply/demand of commissioning providers. Paybacks also vary depend on these variables as well as the quality of the commissioning provider. Direct and indirect benefits of commissioning buildings that factor into payback periods and return on investment include:

- Savings in energy cost and improved building performance
- Improved indoor air quality, comfort and increased productivity by building users
- Early detection of potential problems (the sooner problems are resolved, the less expensive they are to fix)
- Fewer change orders to the owner during construction
- Precise tune-up and operation of systems and applicable controls
- Better building documentation
- Trained building operators and maintenance staff
- Shortened occupancy-transition period
- Reduced maintenance, operation, and equipment replacement cost

(Industry Pages: Two Steps to Commissioning Success; By James H. Shoop, CCP Secretary, Building Commissioning Association)

Retro-commissioning of existing building costs vary in much the same way as commissioning for new buildings including complexity of systems, number of pieces of equipment, and the objectives or scope of the retro-commissioning project rather than by building type. In a study of 44 existing buildings showed a cost of between $10,000 and $52,000, resulting in whole-building energy savings of 5-15%. These costs resulted in a square foot cost of $.05 to $.43. Retro-commissioning of existing buildings delivers simple paybacks on investments that rarely exceed 4 years, and were often 2 years or less. Benefits of retro-commissioning existing buildings include:

- Identifies system operating, control, and maintenance problems
- Aids in long-term planning and major maintenance budgeting
- Helps ensure a healthy, comfortable, and productive working environment for occupants
- Reduces energy waste and ensures that energy-using equipment operates efficiently
- Provides energy cost savings that often pay back investment

- Reduces maintenance costs; reduces premature equipment failure
- Provides complete and accurate building documentation; expedites troubleshooting
- Provides appropriate training to operating staff to increase skill levels; increases staff effectiveness in serving customers and tenants
- Reduces risk and increases the asset value of the building

(A Practical Guide for Commissioning Existing Buildings; By Tudi Haasl, Portland Energy Conservation Inc. and Terry Sharp, Oak Ridge National Laboratory)

F. Summary

The research conducted above in part 3 of this section will be summarized and a commissioning use recommendation for what types of building will benefit most from the commissioning and retro-commissioning processes. The recommendations given for use of commissioning given are not intended to be the final decision makers for the implementation of commissioning or retro-commissioning, instead a simple basic guideline that can be implemented in the early stages of the decision making process. Other project and owner specific issues will need to be accounted for on a project by project basis in order to determine if these processes should be implemented.

a. Summary of Research-

The research conducted in part 3 of this section was conducted with the intent of determining the differences in the processes of commissioning new construction and retro-commissioning of existing facilities. This is meant to be a summary of basic principles and standards as each project may vary from the normal procedure depending on specific need or specifications.

The first and most obvious difference between commissioning and retro-commissioning is at what stage they begin. Commissioning of new buildings begins as stated in its description at some point in the planning/design through construction of a new building. Retro-commissioning however is a term used to define the commissioning process performed on an existing building that has not previously utilized commissioning. This obvious difference plays a major role in what steps are performed in the commissioning process.

As most buildings are designed, built and occupied before there is a plan in place for their operation and maintenance this can lead to premature equipment failure and higher energy costs if poor operation and maintenance is present. Commissioning can benefit these buildings by verifying that equipment is installed and operating properly, resulting in a longer lifespan, increased operating reliability and fewer repairs. As well as ensuring that building documentation is accurate and complete. This benefits the owner as well as the contractor with

lower operating and maintenance costs for the owner and fewer call backs to the contractor.

The commissioning of fit-out spaces that would be implemented for Lancaster General Hospital 5th and 6th floor fit-out project would follow the method for commissioning of new building systems. This is because even thought the project takes place within an existing building all of the mechanical systems that will support the 5th and 6th floor shell space will be new units installed during construction.

The first step of the commissioning process which includes development of commissioning objectives, hiring of commissioning provider, development of design phase commissioning requirements, and choosing the design team would remain the same for the most part except the selection of the design team. This is because Lancaster General Hospital uses the same design team for almost all of their work to maintain a level of consistency. An outside commissioning consultant would have to be identified as neither the design team or contractor for the project has a commissioning professional on staff.

The second step of the commissioning process would also remain mostly the same with commissioning review of design intent, writing of commissioning specifications for bid documents, awarding of job to contractor, and development of commissioning plan. The changes would in awarding of job to contractor because Benchmark Construction Company, Inc. bids jobs for the hospital on a negotiated bid basis. Therefore the commissioning specifications for bid documents would needed to be coordinated with Benchmark in order to obtain a budget for the project.

The remaining three steps in the commissioning process would remain mostly intact with training of operators and maintenance personnel being conducted with the plant engineering staff for Lancaster General Hospital who conduct all operation and maintenance work for the hospital and their facilities.

Some issues with utilizing commissioning on this project would be the learning curve involved with the inexperienced owner, contractor and subcontractors for the project. The design team also has minimal experience with

the commissioning process. Some of these issues could be minimized by holding meetings with the commissioning agent to explain the process in detail and answer any questions. However, since hospitals utilize many complex systems commissioning could help improve the long-term efficiency of the spaces being fit-out in this project.

b. Commissioning Use Recommendations-

Based on the research conducted in the creation of this report there are several items that should be considered while making the decision to utilize commissioning or retro-commissioning on a project. These items include the intended use of the building, complexity of systems used in the building, owner's goals, and availability of commissioning personnel.

Buildings that contain laboratory spaces or healthcare facilities tend to have more complex mechanical, electrical and piping systems. For this reason these types of buildings may benefit more from the commissioning process than buildings such as warehouses. These types of facilities also tend to have complicated control systems that need to function properly in order for the systems to meet their potential. At least on a general basis it is safe to say that these types of buildings would benefit from the testing and documentation that comes with the commissioning process to ensure that the systems are operating as specified which will help them run more efficient, therefore reducing operating costs and comfort issues.

The goals of the owner also play into the decision making process of whether or not to utilize the commissioning process. If an owner such as a developer is constructing the building they may be more interested in first cost because they will not own the building long enough to recoup the savings. Also depending on the owner's budget for construction and yearly operation and maintenance it may be easier for them to absorb the increased yearly costs than the first cost increase.

The availability of experienced commissioning personnel can have an affect on the cost of commissioning a project; therefore this may also play into the decision making.

G. Bibliography

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