A White Paper from the Experts in *Business-Critical Continuity*™

Commissioning Your Data Center for Greater Availability, Safety and Efficiency While Reducing Costs Throughout the Life Cycle

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Executive Summary

Commissioning has existed as a discipline of the building construction industry for nearly three decades. Yet, the commissioning industry is continually evolving and commissioning activities are still being defined by practitioners and industry organizations. Despite widely available standards, there is still considerable difference of opinion as to the definition of commissioning and the processes involved. As a result, commissioning is generally misunderstood and some of the most valuable commissioning processes are underutilized.

In the data center world, commissioning is a relatively new concept. Data center owners have even less of a clear picture of the purpose and value of this important process. Many owners lack an understanding of how, when, and why commissioning should be implemented as a part of the design/build of a new system or process.

The purpose of this white paper is to clearly define commissioning and its application in the data center environment. Data center owners will gain perspective on the value the commissioning process can deliver and learn best practices for realizing the greatest return on their commissioning investment.

Defining Commissioning

While the definition of commissioning varies greatly from one commissioner to the next and one building owner to the next, industry experts generally concur that commissioning is an owner's quality assurance program that ensures a new data center process, system, or addition meets the owners' needs.

Specifically, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) asserts that the focus of commissioning is "verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the needs of the owner." The Building Commissioning Association (BCA) adds that the basic purpose of commissioning is "to provide documented confirmation that building systems function in compliance with criteria set forth in the Project Documents to satisfy the owner's operational needs."

In most cases, the term commissioning refers to newly built processes and systems; however, existing systems can also be commissioned. Retro-commissioning can be performed to analyze and optimize the performance of systems that have already been designed and built. Systems or assemblies that have been previously commissioned may be re-commissioned to improve ongoing performance and efficiency.

Whether the system to be commissioned is new or existing, the objective of commissioning activities always ties back to meeting the owners' needs. As such, the owner is the best person to oversee the commissioning process. However, rarely does the owner have the time or expertise to fill this role.

Owners typically hire a Commissioning Authority (CxA), such as Electrical Reliability Services, Inc. (ERS), to provide building commissioning services, and oversee and execute the entire commissioning process. Unlike a Commissioning Agent, who has legal authority to make decisions on behalf of the owner, the CxA does not have any decision-making power. However, a quality CxA will offer the expertise, guidance, and direction the owner needs to make informed commissioning decisions and realize the most value from the process.

Scope of Commissioning

One of the biggest challenges for owners investing in the commissioning process is the lack of a consistent approach from commissioning firms. Some commissioners primarily provide administrative oversight, creating a pathway for paperwork to flow. Other commissioners, including ERS, adopt a hands-on approach, fully engaging in activities ranging from defining the owner's needs in the pre-design phase, to conducting field tests and verifications, to overseeing the warranty review post occupancy.

To further complicate matters, a general misconception exists that assumes commissioning and acceptance testing are one in the same. In fact, acceptance testing is a separate testing requirement—often reviewed by the CxA—that ensures individual components or pieces of equipment are installed properly and will operate according to the manufacturer's specifications and industry standards. While certainly a critical step, acceptance testing is just one component of a much more comprehensive commissioning process.

In the same vein, commissioning has also been confused with equipment startup. Once again, a CxA often witnesses the installation and startup of critical equipment and entire systems; but like acceptance testing, startup is merely another individual construction activity that is often overseen by commissioners.

Because of these inconsistencies and misconceptions, it is not uncommon for owners to request proposals from a handful of different commissioners and end up with a set of very different recommendations, accompanied by widely varying price points. It can be difficult to compare one bid to the next. Nonetheless, hiring a knowledgeable commissioner with a team-oriented approach can provide value that far exceeds the commissioning fee.

The Argument for Commissioning

In the midst of these discrepancies, how then, can a data center owner determine the appropriate scope of commissioning activities for their project? To answer this question, it is prudent to consider the reasons why more and more data center owners are investing in commissioning.

The major impetus behind commissioning data center systems and processes is the increasing complexity of the systems themselves. This complexity presents more opportunities for problems. At the same time, there is less and less tolerance for unplanned downtime. Due to the staggering cost of unplanned outages or failures, today's data centers must operate reliably 100% of the time.

Appropriate commissioning activities can ensure uptime by identifying the culprits behind data center failures and outages. Nearly 70% of early equipment failures can be traced to design, installation, or startup deficiencies. Unnecessary outages are often due to improper coordination and calibration of protective devices, wiring errors, design errors, and human error. Commissioning can help to detect and correct these problems before the failures or outages occur.

Commissioning is also the answer to a wide variety of other owner concerns. Issues such as ensuring that the operations and maintenance (O&M) staff have adequate resources and training, improving the safety of the data center, and boosting data center efficiency can all be addressed by specifying the right commissioning activities.

The appropriate scope of commissioning, then, relates directly to owners' requirements for their data centers. It is the opinion of ERS that a comprehensive approach to commissioning—one that encompasses a wide range of building systems and spans the entire design/build process, from pre-design through occupancy—results in the greatest value to the project owners.

The Commissioning Process

Frequently Commissioned Systems in Data Centers

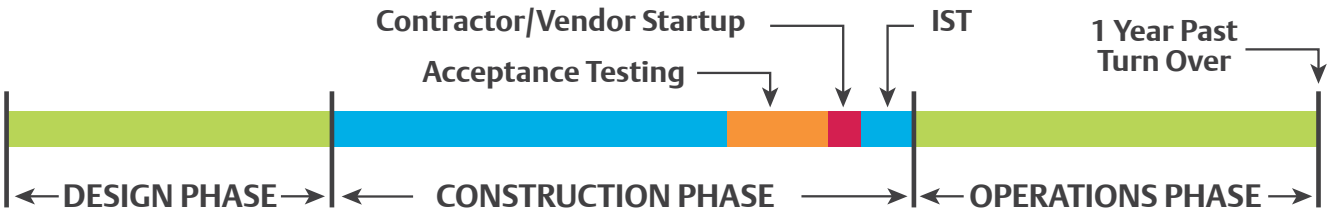
Historically, commissioning was reserved for a building's electrical and mechanical systems. Today, the entire building and all of its systems and processes can benefit from commissioning. While owners may choose to commission anything and everything from specialty systems—such as security and fire/life safety systems—to structural systems and the building envelope, the most frequently commissioned systems in data centers include:

- Electrical distribution equipment and systems
- Mechanical and HVAC systems
- Monitoring and controls systems
- Specialty systems (EPO, security, VESDA, fire/life safety, etc.)
- Lighting controls
- Structural systems

Phases in the Commissioning Process

It is helpful to think of commissioning as a process, ideally from the planning phase or pre-design phase through one year of occupancy. From setting the project goals prior to design, to accounting for warranty issues after turnover, the commissioning process can provide value throughout the project.

This basic project timeline shows the typical span of a comprehensive commissioning program:



Depending on when the CxA becomes involved in the project, commissioning activities generally occur in accordance with the three major phases.

- **Phase 1: Pre-Design/Design**
  During the pre-design or design phase of a project, the first priority of the CxA is to help determine and document the Owner's Project Requirements (OPR). The OPR becomes the keystone of the commissioning project, and the CxA will make sure that all commissioning activities align with meeting these requirements.

  Based on the OPR, the CxA will develop the written commissioning plan. The plan will identify systems to be commissioned and define the scope and schedule for all commissioning activities.

  Throughout the design process, the CxA will work closely with the design team to complete design reviews and make recommendations on design plans and documents, ensuring that the design of the data center meets the OPR. During this phase, the CxA will make sure quality systems and acceptance testing are specified for execution during the construction phase and will also help to establish training guidelines for O&M staff.

- **Phase 2: Construction Phase**
  Installation, startup, and acceptance testing of systems, equipment, and assemblies within the data center occur during the construction phase of the commissioning process.

  The CxA will review submittals of commissioned equipment and controls, and ensure that all systems and assemblies are properly installed prior to startup. The CxA may witness vendor startup of critical equipment.

  It is the CxA's responsibility to develop functional and systems testing procedures and conduct all functional and systems tests. Tests should be performed in all operational modes and the CxA will document any problems or weaknesses that must be addressed. The goal of the tests is to ensure that all systems and assemblies operate properly and work together in accordance with the OPR.

  Late in the construction phase, the CxA will help prepare systems operating documentation and ensure that O&M staff receive training based on the training requirements established during the pre-design/design phase of the project.

- **Phase 3: Occupancy Phase**
  After construction of the data center is completed, commissioning activities can continue up to one year post occupancy. During the occupancy phase, the commissioning team will perform any deferred or seasonal testing that could not be completed during construction.

  The occupancy phase also includes an adjustment period during which changes may be made to systems and equipment to ensure optimum operation. Items in need of adjusting may include circuit breaker settings, time delays of transfer switches or transfer schemes, temperature set points, timing or level settings for lighting programs, and the rotation schedule for HVAC equipment, just to name a few.

  During this phase, and prior to the expiration of the original construction warranty, the commissioning team can conduct a warranty review to identify any issues to be corrected by the general contractor.

  Finally, the occupancy phase should include a lessons learned workshop that involves the commissioners, design and construction teams, and O&M staff. The workshop is an opportunity to discuss the project's successes as well as its challenges, and determine what improvements can be made in the future.

Commissioning Best Practices

Understanding the full scope of potential commissioning activities is the first step to realizing the greatest value from the commissioning process. From there, owners can ensure the

highest return on their commissioning investment by implementing the following commissioning best practices.

Hire an Independent CxA

Hiring an independent CxA allows owners to acquire the most comprehensive and well-balanced approach possible while avoiding potential conflicts of interest that would filter or limit commissioning communications to the owner. The commissioning industry recognizes that potential conflicts of interest may be difficult to avoid entirely, considering the possibility of relationships on past projects, connections to other companies involved on the project, and other factors.

In particular, industry best practices and LEED requirements seek to provide a level of separation between the CxA, the general contractor, and design team. It is recommended that, regardless of affiliation, the CxA have a direct line of communication to the owner.

For a truly objective perspective that is not marred by any conflicts of interest, the CxA must be an independent third party, under direct contract to the owner, with no other project responsibilities other than commissioning activities.

Choose a CxA with the Right Credentials

In addition to being an independent third party, the chosen CxA should have experience commissioning critical spaces or mission-critical facilities. The CxA should have specific expertise in project documentation as well as field commissioning of the equipment in the project scope. Owners should be sure that the CxA has developed documentation for the commissioning process (OPR, commissioning specification, commissioning plan, etc.) as well as comprehensive systems testing procedures.

Ideally, the CxA should participate in major industry associations and be staffed with individuals with the appropriate credentials. For example, ERS is a member in good standing with the Building Commissioning Association and InterNational Electrical Testing Association (NETA) among other organizations. The ERS staff includes Certified Qualified Commissioning Providers (QCxP), NETA-certified field engineers, and LEED Accredited Professionals (AP) with training in ASHRAE commissioning guidelines and the LEED rating system.

Start Early

Ideally, the commissioning process should begin during the pre-design or design phase of a project. Beginning the process well before construction starts—or better yet, before an engineering firm has been hired or design specifications determined—allows the CxA to help determine the OPR first and foremost and provide detailed guidance to all project teams, beginning with the design team. Aligning the design with the OPR gets the project off to the right start and reduces re-work and schedule delays later in the process.

Additionally, involving the CxA early sends a clear message to the design and construction teams that commissioning is an integral part of the design/build process. This ensures better collaboration between commissioning, design, and construction teams, and can motivate the design and construction teams to fully participate in commissioning activities.

In practice, many owners do not engage the CxA until the construction phase of the project. In these cases, the CxA is unable to ensure that the design itself meets the needs of the owner. While benefits of commissioning can still be realized, the value of the process is reduced.

Invest in an OPR

The importance of the OPR document cannot be overstated. It represents the true purpose of commissioning—meeting the owner's needs—and serves as the foundation upon which all commissioning activities are based. The document also provides a way to measure project success.

Ultimately, system design, construction, and operation schemes should all map back to the OPR.

Despite the critical nature of this document, only a small percentage of projects actually utilize one. Owners may generalize their expectations and desires for the new data center process or assembly—such as needing increased availability or the use of a specific type of equipment, but often, they fail to invest the time and effort to generate a comprehensive OPR document.

Typically, a quality OPR document will include the project schedule and budget, commissioning scope and owner directives. In addition, the owner may stipulate requirements based on the priorities of the project, including:

- Sustainability goals (LEED)
- Energy efficiency goals
- Owner directives
- Project documentation
- Systems integration
- User requirements
- Occupancy requirements and schedules
- Interior environment
- Accessibility
- Constructability
- Operation and maintenance criteria
- Equipment maintainability expectations
- Training
- Warranty
- Security
- Benchmarking
- Future expandability needs
- Seismic
- Restrictions and limitations

The OPR document is ideally created during an OPR workshop. The workshop can be conducted by the owners and/or their CxA. It should be based on a scientific model, such as the modified group technique, for eliciting the greatest amount of information during a brainstorming session. Ideally, all project stakeholders should be represented at the workshop. Stakeholders can include anyone from executive management and project managers, to O&M staff, internal and external customers, janitorial staff, and even members of the community.

Workshops typically generate a significant number of potential requirements to incorporate in the final OPR. A good CxA will be an expert at helping owners articulate their requirements for the data center during the workshop and should be able to provide insight and recommendations, including lessons learned from previous projects. It is the owner, however, who must be the final decision maker as to key project requirements.

Once the OPR is finalized, it should be shared with the design team. The design team should provide input as to how each requirement will be fulfilled by the design, typically as the Basis of Design (BoD).

Involve the Right People

Commissioning efforts are the most successful when they have full buy-in from all critical parties, beginning with the owner and including the design team, general contractor, subcontractors, and equipment vendors.

Each of these parties will have specific responsibilities and duties to perform throughout the commissioning process. For example, the design team and the construction team should give input on the functional tests developed by the CxA. The design team should weigh in on testing procedures and technical review. All parties will need to collaborate on testing schedules.

The data center owners will obviously be key players in the process and must authorize and approve all commissioning documents and activities. Owners' participation will set the tone for all other players. When owners are truly invested in the commissioning initiative, their support will filter

down and help ensure everyone's involvement. If both the owners and the CxA promote a team approach, where all parties are working toward the common goal of accomplishing objectives successfully the first time, it greatly increases the chances for collaboration and a successful project.

Establish Priorities for the Commissioning Budget

Industry experts agree that the ideal commissioning budget for a complex data center should be about 1.5% of total construction costs. In reality, however, budgets are rarely this liberal making it nearly impossible to commission all building systems, equipment and assemblies. It falls to the owner—with help from the CxA—to prioritize the budget to determine which commissioning activities will deliver the greatest return on investment.

In typical office buildings, owners are most concerned with the comfort, health, and productivity of employees and will therefore commission systems that contribute to employee well-being and efficiency. However, in data centers, where downtime can cost literally millions of dollars per second, availability is almost always priority one, followed closely by safety, efficiency, and cost cutting.

Availability of Critical Infrastructure
To ensure data center availability, commissioning activities should focus on verifying that critical support systems—namely the power system, cooling system, and IT infrastructure—are designed for maximum uptime, as specified in the OPR.

Commissioning activities will likely include procedures to inspect and test the systems to verify performance under all operating conditions, looking for redundancy and single points of failure. For example, commissioning will confirm that, in the event of a power failure, the HVAC system will come back online well before the operating computer servers drive the room temperature high enough to cause server failure.

Commissioners may also recommend and/or ensure the inclusion of other means of improving data center availability, such as adding equipment maintenance schedules to the O&M documentation.

Data Center Safety and Compliance
To ensure the safety and well-being of all data center O&M staff and avoid liability, data center owners must provide a safe operating environment and adhere to all safety and compliance regulations.

Commissioning can improve safety during every phase of a project, beginning with ensuring the inclusion of safety in the OPR document. During design reviews, inspections, testing, and the occupancy phase, the CxA will identify safety hazards and make recommendations for correcting them. The CxA may also make recommendations for safety-related maintenance practices to ensure compliance with NFPA 70E guidelines. The CxA can ensure that safety topics are incorporated in training and covered in O&M documentation.

Cost Cutting
Today, many data center owners are shifting their focus from building capacity to reducing costs. For these owners, improving energy efficiency is one of the most effective ways to reduce operating costs.

Commissioning can verify that the efficiency features designed and built into a new system function as intended and produce the expected energy efficiency. The commissioning team can also measure the energy consumption of specific systems, equipment, and assemblies, and when necessary, suggest alternate equipment or control schemes to meet the efficiency needs of the owner.

Additional Budget Priorities
Once system availability, safety, compliance, and energy efficiency have been addressed, a number of other commissioning activities can add significant value to a data center project. The following commissioning activities are requirements for projects seeking LEED certification; but even if a project is not attempting this designation, data

center owners may want to strongly consider including these initiatives in the commissioning budget:

- **Development of Systems Manual and Operating Procedures**
  Human error is very often at the root of data center disruptions. Fortunately, many mistakes can be avoided with well-written, high quality operating procedures. The commissioning team can work with the general contractor to prepare a Systems Manual, as well as written operating procedure for building systems and assemblies that will help prevent the mistakes that jeopardize mission-critical operations.

- **Training**
  In addition to documented operating procedures, a well-trained and knowledgeable O&M staff is key to data center success. The commissioning team can help ensure that training is a quality effort. The CxA can verify that equipment vendors and control contractors provide appropriate training on the construction, theory of operation, maintenance, troubleshooting, and safety concerns specific to their equipment or system. Additional commissioning activities can include reviewing the training schedule to ensure adequate time for trainees to absorb information; ensuring trainer qualifications; verifying the appropriateness of the training area; ensuring the quality of training handouts; and verifying that training meets NFPA 70E requirements.

- **Warranty Review**
  The CxA can oversee the on-site warranty review. The CxA will ensure that any operational issues under warranty are identified and addressed by the contractor before the warranty period expires.

Lower Budget Priorities

Some data center owners elect to commission systems such as the fire protection, lightning protection and security systems. While each of these systems is important, they are often lower priority items for many data center projects because they are not mission-critical support systems. What's more, other authorities including the local fire department, govern systems such as the fire protection system. These authorities oversee the design, installation, and testing of the system, often making commissioning somewhat redundant.

Dedicate Enough Time to the Occupancy Phase

Data center owners sometimes make the mistake of shortchanging the occupancy phase. However, this phase is critical to the commissioning process. The commissioning team cannot verify that systems are actually operating in accordance with the owners' requirements until those systems are fully operational, which doesn't occur until this phase of the project.

Additionally, some critical tests and training can only be performed once systems are operating. Other tests may have been deferred until the occupancy phase because of weather conditions.

Finally, the occupancy phase provides the final opportunity to perfect all commissioned systems and assemblies. The CxA will help identify problems that must be fixed under the warranty agreement, and will fine-tune and optimize system performance.

Benefits of Commissioning

Commissioning can deliver a wide range of benefits for data center owners. When best practices are followed and the appropriate commissioning activities are specified, the data center owner will be rewarded with systems and assemblies that meet specific, well-documented project requirements. These systems will also perform in accordance with the design intent. Commissioning helps to ensure that projects are not only successful, but that they are delivered on time and on budget, ultimately creating the highest possible level of owner satisfaction.

Less Unplanned Downtime and Fewer Repairs

Preventing or greatly reducing the possibility of unplanned downtime, which can be devastating to a business, is perhaps the greatest value commissioning provides for data center facilities. Commissioning activities ensure that mission-critical equipment is properly installed and that systems are fully integrated. The process checks for redundancy and single points of failure. It includes comprehensive system testing to verify availability in all operating modes. These activities help identify potential system-related problems so they can be resolved before leading to major equipment damage or a disruption of service. Commissioning can also ensure a well-trained and well-equipped O&M staff that is less likely to make mistakes that lead to system failure.

Reduced Life Cycle Costs

Done properly, commissioning improves system performance throughout the life cycle of a data center. Better system performance not only optimizes data center performance, it also decreases operation and maintenance costs and cuts down on energy consumption for smaller utility bills.

Single-Source Accountability

The CxA streamlines all commissioning and quality assurance efforts, advises the contractor on project schedules, and provides single-source accountability throughout the entire process. Project owners benefit from the convenience and efficiency of one, go-to source for project information, communications and updates.

Fewer Change Orders and Delays

Under the CxA's oversight, projects experience fewer change orders, delays, and rework, avoiding the considerable costs of late occupancy, liquidated damages, extended equipment rentals, and other costs associated with delays.

Cost-Effective Problem Resolution

The commissioning process helps identify system-related problems early in the project when it is most economical to correct the issues. For example, design problems are identified during design reviews as opposed to late in the construction process when it is much more time consuming and costly to correct them. Installation issues are pinpointed before system startup, and O&M process problems are noted before a component fails.

Full System Integration

For maximum data center availability, all critical systems—power, cooling and IT infrastructure—must function together as a fully integrated system. Historical approaches to testing and startup verified only that each individual system components functioned independently. Today, a CxA employs more sophisticated processes and tests to verify that components work together as an integrated system.

For critical space facilities, an Integrated Systems Test (IST) is often the final, major test event. The IST verifies collaborative operation of the electrical, mechanical, and controls systems under designed loads with a variety of normal and adverse operating conditions.

Informed Workforce

One of the outcomes of the commissioning process is a robust knowledge base about the new system or process, which can be translated into quality training activities, training materials, and O&M resources. Involving the CxA in the training process and Systems Manual preparation ensures that the O&M staff is well prepared and well equipped to operate and maintain the newly commissioned system. In addition, both veteran staff and new hires will have quality references for future training, refreshers, or troubleshooting.

Benchmarking Data

Commissioning creates extensive documentation for benchmarking system changes and trends. The data can be used to identify future problems with the system or process, maintain optimal operations, and evaluate future maintenance decisions.

Improved Efficiency

If efficiency features have been designed and built into the new system, commissioning activities can verify that the features function as intended. Commissioning can also ensure that the O&M staff has the training and operating resources it needs to fully leverage the design efficiencies. Thus, the owner will be able to realize the intended energy efficiencies and the resulting energy cost savings.

Enhanced Safety and Compliance

The commissioning process produces a safer data center and reduces owner liability by uncovering safety problems throughout the design, construction, and occupancy phases of a project. Commissioners can verify compliance with NFPA 70E safety-related maintenance practices. The CxA also ensures that owners and O&M staff receive proper education on safe operating and maintenance procedures pertaining to electrical and mechanical equipment.

LEED Certification

Commissioning is a requirement for LEED certification. Projects attempting the certification must complete basic commissioning activities and can complete enhanced commissioning activities for optional credit.

LEED projects must involve the CxA mid-way through the design phase or earlier. During this phase, the CxA can assist with making the application for LEED certification. The CxA will also assist with the design phase submittal to verify that LEED design requirements have been met, as well as construction phase submittal to verify that LEED construction requirements have been met.

Return on Investment

The benefits of commissioning often create a return on investment that far exceeds the cost of the commissioning project itself. In all recent ERS projects, cost/benefit analyses of key issues discovered and corrected during the commissioning process revealed value for the owner beyond the cost of commissioning. These analyses took into account only material and labor costs and did not factor in the cost of data center downtime that likely would have occurred had the identified issues not been resolved.

Conclusion

Despite the differences of opinion in the data center industry as to what the commissioning process should entail, commissioning is verifiably a critical step in the design and build of a new data center facility, system or addition. To glean the greatest value from commissioning, data center owners must first consider the fundamental rationale for commissioning—ensuring that project requirements are met. The owner should then look for a CxA, such as ERS, that offers a scope of services broad enough to encompass all requirements.

By following commissioning best practices including engaging the CxA early in the design process, creating a quality OPR document, and prioritizing the commissioning budget—data center owners can be assured a project that meets their requirements. Once turned over to the owner, commissioned systems will operate as intended, personnel will have the necessary training, and O&M staff will have the resources to operate data center systems safety and efficiently.

In addition, commissioning leads to greater data center availability, safety, and efficiency while reducing project and operating costs throughout the life cycle of the data center. Commissioned data centers are more likely to be delivered on time and on budget. Ultimately, commissioning produces a higher level of owner satisfaction with the completion of a data center project and for many years to come.

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