Maximizing Uptime in Mission-Critical Facilities

White Paper 7

Revision 0

by Joe Soroka

> Executive summary

As technology reaches into every corner of our world, the importance of, and reliance on, your mission critical facility reaches new heights. Uptime is no longer a lofty goal, it is an absolute necessity. However, uptime is not a product that you specify with the design of your facility, install, and then forget about. A facility designed to 99.99% of availability will not achieve / maintain that number, unless we fully understand the many factors that affect uptime. Maximum Uptime is a philosophy. It begins with the planning of your facility, and remains a continuous process through every step of design, construction, commissioning, operations, failure analysis, and recommissioning.

Contents

Click on a section to jump to it

APC white papers are now part of the Schneider Electric white paper library produced by Schneider Electric's **Data Center Science Center**
DCSC@Schneider-Electric.com

Lessons learned long ago help us achieve uptime today

September 17, 1908: Orville Wright's flying machine crashes at Fort Meyer, Virginia, killing co-pilot T.E. Selfridge, and an aircraft accident investigation board is born. The Aeronautical Board of the U.S Army Signal Corps and the Aerial Experiment Association (AEA) headed by Alexander Graham Bell and his associates conducted a thorough accident investigation. Through their findings, Dr. Bell realized the importance of preventing failures in the future and wrote an article entitled "The Lessons to be learned from Orville Wright's Disaster".

"Lessons Learned" have become an essential tool in the prevention of aircraft accidents. Today, based on their investigation into the cause of an accident, the National Transportation Safety Board (NTSB) develops and issues "lessons learned" to prevent similar failures in the future. Preventing failures in mission-critical facilities requires a similar approach to ensure maximum uptime.

Four categories of failure

NTSB investigations establish that accidents occur due to one or more types of failures: design failures, catastrophic failures, compounding failures or human-error failures. Downtime at mission-critical facilities can be attributed to these four types of failures, as well, and each requires a different approach on prevention. All four types of potential failures must be examined, and "lessons learned" programs established in order to realize Maximum Uptime for your Mission-Critical Facilities.

Design failures can be eliminated by first engaging with competent vendors. Selecting the appropriate design firm, integration firm, construction companies and commissioning team along with the operations staff is crucial to acquiring the experience needed to reduce these types of failures.

Catastrophic failures are usually unpredictable in nature. However, a comprehensive maintenance and operations programs can identify and eliminate as many potential problems as possible. This can also help eliminate the condition that contributed to the weakness and minimize the effects of truly unpredictable problems.

Compounding failures are caused when multiple events occur to create a failure. The lack of attention to details is a leading cause in compounding failures. Little nuisance items in a large facility are sometimes left unnoticed and by themselves cause no ill effect to the facility, but along with other problems, can combine to create a system failure.

Human-error failures are a leading cause of failures in mission-critical facilities. These failures can be reduced by having an experienced staff that receives continuous training. Even with a competent and trained staff, the requirement for switch-level, detailed Methods-of-Procedure (MOPs) are still required. These MOPs should be executed with a pilot/co-pilot approach.

Planning

Begin with the end in mind. Whether it's new construction, upgrading or operating an existing mission-critical facility, it is important to carefully plan the work and to work the plan. In the design phase, it is important to consult with design teams experienced in the design of the particular type of mission critical facilities that your organization requires. A crucial part of the design phase is the early development of the Design Intent.

Unfortunately the Design Intent too often is not fully developed, or is vague. The Design Intent should clearly state the owner's requirements. A well-created Design Intent document will start with a narrative of the project background, and provide a detailed discussion of the required objectives and goals. Required functional uses and requirements of the mission-critical facility should be clearly explained. While often difficult to quantify, performance and maintenance criteria should also be addressed. Finally, the expected lifespan and overall quality of the project needs to be defined.

A comprehensive Design Intent is crucial for all involved parties to succeed in achieving maximum uptime in a mission-critical facility. Without it, too much interpretation by the various parties involved, can lead to compromises and misunderstandings that weaken the integrity of everything which follows.

Selecting a design concept

Link to resource
White Paper 122
Guidelines for Specification of Data Center Criticality / Tier Levels

There is not a single ideal facility design configuration. Any of a number of design concepts will accomplish similar goals, each with its own advantages and disadvantages. The required system reliability and project budget will be a driving force. However, there are four basic categories of design concepts;Tier I,Tier II,Tier III, and Tier IV. See White Paper 122, *Guidelines for Specification of Data Center Criticality / Tier Levels*, for more information on this topic.

Tier 1

- Single active delivery path
- Need (N) of capacity
- Site availability of 99.671 %
- Annual downtime of 28.8 hours

Tier II

- Single active delivery path
- Need + Redundancy (N+1) of capacity
- Site availability of 99.749 %
- Annual downtime of 22.0 hours

Tier III

- One active and one passive delivery path
- Need + Redundancy (N+1) of capacity
- Site availability of 99.982 %
- Annual downtime of 1.6 hours

Tier IV

- Two active delivery path
- Need + Need with Redundancy 2 (N+1) of capacity
- Site availability of 99.995 %
- Annual downtime of 0.4 hours

Equipment selection and integration

Selecting the right equipment vendors for the project helps ensure its successful completion. It is crucial to ensure that the equipment vendor meets the engineering specifications. Beyond the equipment-side however, the vendor's ability to support the equipment is an equally important consideration. This includes delivery times, installation support, start-up services and the availability of spare parts and authorized maintenance personnel.

For complex systems and fast-track projects, consider using an equipment integrator. Complex systems rely on the operation of multiple systems and platforms. Therefore, it is essential to have the support of an organization focused on the overall connectivity and interaction of multiple systems. A qualified integrator can help eliminate the confusion that multiple Request for Information (RFIs) from various installing contractors can cause. Integrators provide the owner with a single point- of-contact, reducing the project's completion time, and ensuring that all of the systems are properly installed and interconnected.

When selecting equipment for your mission-critical facilities, work with an Integrator to verify that all of the equipment complies with the project specifications. Listed below are some equipment options to consider for a mission-critical facility.

Generators
When selecting the generator, review the technical specifications to ensure that your project needs are met. Review the generator's available options. For example, optional isolation valves on the jacket water heater hose are inexpensive at the time of purchase. Replacing the jacket water heater hose in the field however, will require taking the generator out of service for an extended period of time. Another generator option to consider is auxiliary breaker contacts. Generator outages caused by a tripped or open generator breaker are surprisingly common. In addition, monitor and/or alarm the auxiliary contacts. The generator is there to provide power in the case of an outage, make sure it is ready when needed.

UPS Systems
There are as many different types of UPS systems as there are topologies. Your requirements may be best suited for a double conversion, line interactive or delta conversion. Regardless of the type of system that fits the application, make sure the appropriate internal and external maintenance bypasses are installed. A maintenance bypass should be sized to support 100% load on external maintenance bypass while providing enough capacity to perform 100% load tests.

UPS Batteries
When using Valve Regulated Lead Acid (VRLA) batteries, specify multiple battery strings that can be independently isolated by opening a breaker. With an independently isolated VRLA battery string, maintenance can be performed while keeping the critical load on the UPS system.

Monitoring

Link to resource
White Paper 104
Classification of Data Center Management Software Tools

When selecting a monitoring system, understand the system's capabilities and establish the various alarms, trends and notification to provide not only alarm notification, but also important historical data that can be used to predict and prevent failures. It is, of course, essential that the monitoring system itself continues to operate when the systems that are being monitored fail. Proper setup of monitoring system alarm points is crucial to preventing failures and/or minimizing their impact. For more information on data center management software see White Paper 104, *Classification of Data Center Management Software Tools*.

Setting the pace

Developing a realistic project schedule and updating it throughout the project will help eliminate unwanted surprises and avoid delays. When developing the schedule, determine the required milestones and list the items that can impact them.

Construction

Well-planned and meticulously implemented construction is the key foundation to facility reliability and maintainability. The owner should take an active role in selecting and working with the team throughout the construction process. A team approach to building your mission-critical facility will help to ensure that your final product will meet your specifications.

Safety first

Insist on vendors providing safety plans before any work begins. Review the plans to ensure they're current and appropriate to your project. Injury and fatalities can affect the reputation of your organization, along with the potential for OSHA fines and other litigation costs. An unsafe project will add additional costs and delays to the project. Invest the upfront time to ensure the project site is safe from the beginning. It will save time, money and possibly lives.

Construction Inspections

The owner, or the owner's representative, should conduct regular inspections of the jobsite during the construction process to document and photograph the installation process. Any items of concern should be addressed immediately rather than waiting until after the installation is completed. Correcting construction issues at the time they occur will help to ensure that the project stays on schedule and within budget. Along with inspecting for proper installation, inspection for proper safety procedures, overall organization and cleanliness is a must. A dirty, disorganized and unsafe construction site can lead to accidents, delays and mistakes.

Construction Meetings

Conduct regular construction meetings that are professional and productive. Building a fast-track project for a mission-critical facility requires a team approach and a team is most effective working in unison. Good facilitation and mediation skills can be tremendous assets. Professionalism, Team Work and Expertise will deliver a quality project on time.

A keep sake moment

Keeping a detail construction log along with digital pictures is very helpful to a project. After the site is operational, there will come a time when you will want to refer to the construction photos to see how a piece of equipment was installed. Well-organized construction photo albums will provide a wealth of information years after the project's completion when the operations staff must perform maintenance, upgrades or repairs.

As-built drawings

After the installation, be sure to secure the project's as-built drawings. Invest the time to verify the accuracy of the drawings. Then institute a practice that ensures that all applicable drawings are undated as upgrades occur at the facilities. If they do not exist, a set of as-built drawings should be developed. As-built drawings are valuable tools in quickly resolving problems and restoring service in the event of a failure. Additionally, they are valuable when initiating facility upgrades.

Commissioning

Commissioning is the systematic process of verifying and documenting the performance of the facility's equipment. This process has several distinct phases, including the Planning Phase, Design Phase, Construction Phase, Acceptance Phase and the Post-Acceptance Phase. Commissioning a facility has many benefits providing direct and indirect paybacks. Prior to starting the commissioning program, take the time to define the key purpose of the program. For example, systems can be setup to achieve higher energy efficiency, but this may affect the system reliability. Trade-offs between energy efficiency and system reliability must be carefully weighed. This is ultimately a priority-based decision for the owner.

There are a number of benefits to Commissioning a facility, including:

- Improved system performance and reliability,
- Reduced energy consumption,
- Improved environmental controls and
- Indoor Air Quality (IAQ),
- Hands-on training for operations and maintenance personnel,
- Early identification of outstanding issues,
- Verification of operating parameters and procedures,
- Establishing an operating baseline,
- Extended equipment life,
- Reduced occupant IAQ complaints including hot and cold calls.

Commissioning Procedures

All operating procedures should be tested for functionality during the Commissioning process. This includes start-up and shutdown of equipment, equipment bypass and failure-recovery procedures. Equipment should be exercised through all of the modes of operation. To avoid future problems, it is essential to verify all operational modes and procedure methods before the facility is occupied.

Recommissioning

Recommissioning is the process of commissioning a previously-commissioned facility to which changes have been made. The original commissioning documents are used as a baseline for the facility's operating performance. When developing the recommissioning plan, it is important that all new equipment and upgrades are added to the new plan. Since the building is occupied during the recommissioning process, a detailed Method of Procedures must be developed to allow complete testing without affecting the facility operations. This may require temporarily placing equipment out of service, in bypass mode, after-hour work windows and the use of temporary equipment. In the case of a mission-critical facility, great care must be taken to evaluate the system and to develop the correct procedures to ensure the required uptime.

How often a facility is recommissioned is dependent upon several factors, including the required system availability and reliability, the effects of improper performance on operations, energy consumption, energy costs, and the amount of changes and upgrades that have occurred since the facility was last commissioned. Typically, a mission-critical facility should be recommissioned every 3 to 6 years.

Retro-commissioning

Retro-commissioning is the process of commissioning an existing building that has not previously been commissioned. The retro-commissioning process is the same as the commissioning process with the exception that the building is occupied. Since the building is occupied and needs to remain operational, proper planning and development of detailed Method of Procedures will need to occur in the same manner as a recommissioning effort.

Link to resource
White Paper 148
Data Center Projects: Commissioning

For more information on data center commissioning, see White Paper 148, *Data Center Projects: Commissioning*.

Operations

Operations and maintenance (O&M) staffing

Once the site is operational you will need to decide how to staff your facility. Whether you use inside or outside staff it is important that the depth of knowledge meets the requirements of your mission-critical facilities.

Operating Procedures

The development and verification of site operation, maintenance and recovery procedures are vital to maximizing uptime. Methods of Procedure (MOPs) should be very thorough and specific, written to the switch level detail, and tested during the project's commissioning phase. Too often the rush to bring the facility online overshadows the need to develop, document and deploy MOPs. However, waiting to develop a procedure to transfer the UPS system, to maintenance bypass could prove much more costly than investing the time upfront to prepare for the inevitable. Procedures should be developed early and tested before the facility is fully operational.

Maintenance Windows

When designing or upgrading your facility, keep in mind the quantity and length of maintenance windows required to properly maintain the facility. The system will need the appropriate redundancy and bypasses in order to operate while maintenance is performed. An annual maintenance matrix should accompany the equipment list to ensure adequate redundancy allowances. Systems without the appropriate maintenance allowances may require the use of temporary equipment or the installation of additional systems if continuous uptime is a requirement.

Predictive Maintenance

Maintenance should go beyond remedial and preventative maintenance to include predictive maintenance. Using equipment trends and conducting a thorough failure analysis after each incident will help predict and in-turn proactively prevent future problems. All maintenance documentation should be detailed, and provide methods for predicting and anticipating potential trouble spots and weaknesses. Details are the building blocks of a comprehensive predictive maintenance program.

Maintenance Planning

Plan all maintenance in advance. Start with the basics. Develop a complete equipment list and use that as a basis for the planning matrix. Have specific procedures in place for each piece of equipment. The procedures should include start-up, shutdown, bypass, lock-out tagout, maintenance and disaster recovery. Review maintenance windows and implement an automated equipment maintenance schedule that is strictly enforced.

Disaster planning and recovery

A comprehensive business continuity plan (BCP) is required for all mission-critical facilities. It is equally important to develop a comprehensive plan for all IT equipment and supporting infrastructure in your mission critical facility. The plan should be a joint effort between the IT and Facilities departments and should be tested and updated at least once a year and/or as facilities changes occur.

Utilities

The August 2003 blackout affected communities stretching from Detroit to New York. Seconds after the power outage, thousands of generators received a start signal and most of them started. However, dead batteries, low fuel, low coolant, and generally poor maintenance left the others in the dark.

The time to prepare for the next outage is now. In addition to electrical utility outages, mission-critical facilities must also prepare for failures from other utilities, including telecommunications, water, sewer and gas.

In the event of a water outage, sufficient water will be required to support the make-up water used in cooling towers as well as water for staff requirements. Redundant water sources, such as wells and storage tanks, are an important part of a disaster plan.

In the event of a widespread outage, an adequate supply of diesel fuel is also important. During normal times, suppliers are able to provide more diesel fuel within hours, but a widespread outage will severely impact delivery schedules. Generator monitoring can help eliminate a fuel shortage.

Training

It is also important to have a comprehensive training program for the operation and maintenance staff. Training should start with the equipment manufacturer/installer. Start-ups and commissioning offer ideal opportunities for training operation and maintenance staff. Once the site is operational, schedule regular training to keep operational and maintenance staff current.

Conclusion

Ultimately, maximum uptime in the mission-critical facility runs on technology, trust, and teamwork. Your infrastructure integrator works to orchestrate and coordinate the efforts of this diverse team to ensure your mission-critical facility delivers the performance and availability you require.

For an asset as crucial as your mission-critical facility's infrastructure, it pays to invest the time to select a company you can trust, with the experience and resources to maximize uptime and mitigate risk. Ideally, your mission critical infrastructure specialist will offer you all of the products, people, services and strategies needed to design, integrate, commission, staff, maintain, service and monitor your facility. Acquiring these crucial services from a single source can greatly reduce headaches and finger-pointing in the future.

Technology has changed quite a bit in the nearly 100 years since “Orville Wright’s Disaster.” However, learning from failure remains the key to ensuring that history doesn’t repeat itself.

An experienced mission-critical facilities infrastructure integrator can provide essential expertise in preventing failures and ensuring maximum uptime. Whether it’s design failures, catastrophic failures, compounding failures or human-error failures, there are steps that can eliminate, minimize or mitigate their effects. And an ongoing site-specific "lessons learned" program will become a living document that continues to help maximize uptime for your mission-critical facilities. Uptime is not a product and it is never complete. Uptime is a philosophy. It is a never ending process that is practiced, lived, learned and refined every day.

Acknowledgements

Special thanks to **Joe Soroka** for authoring the original content of this white paper.

Resources

Click on icon to link to resource

Classification of Data Center Management Software Tools
White Paper 104

Data Center Projects: Commissioning
White Paper 148

Guidelines for Specification of Data Center Criticality / Tier Levels
White Paper 122

Browse all white papers
whitepapers.apc.com

Browse all TradeOff Tools™
tools.apc.com

Contact us

For feedback and comments about the content of this white paper:

Data Center Science Center
DCSC@Schneider-Electric.com

If you are a customer and have questions specific to your data center project:

Contact your **Schneider Electric** representative at
www.apc.com/support/contact/index.cfm