Developing a Preventive Maintenance Plan for Your Data Center

By:

D. Cole

Experts for Your Always Available Data Center

White Paper

Table of Contents

EXECUTIVE SUMMARY

The proverbial rhyme “For Want of a Nail” aptly illustrates the consequences of small actions not taken.

For want of a nail the shoe was lost.
For want of a shoe the horse was lost.
For want of a horse the rider was lost.
For want of a rider the battle was lost.
For want of a battle the kingdom was lost.
And all for the want of a horseshoe nail.

If this were updated and put into the data center, perhaps this rhyme would begin with the line

For want of effective maintenance the UPS (or CRAC…) was lost.

Data center maintenance is an important component in ensuring maximum data center availability. Maintenance is more than simply a set of procedures. It is an overall strategy that requires clear objectives, well-defined roles and responsibilities, sufficient resources to accomplish the goals, and an organization that is committed to continuous operations

MAXIMIZING DATA CENTER AVAILABILITY

Maximizing data center availability requires four main components:

- Design
- Reliable Components
- Real-time Monitoring
- Preventive Maintenance

DESIGN

Maintenance begins during the design phase. It is important to provide for concurrent maintenance in the data center design. Consider the following table that compares the various tier levels as defined by the Uptime Institute.

	Tier I	Tier II	Tier III	Tier IV
Active capacity components to support IT load	N	N + 1	N + 1	N after any failure
Distribution paths	1	1	1 active 1 alternate	2 active
Concurrently maintainable	No	No	Yes	Yes
Fault tolerant (single event)	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous cooling	Load density dependent	Load density dependent	Load density dependent	Class A
Availability	99.67%	99.75%	99.98%	99.99%
Downtime per year	28.8 hours	22 hours	1.6 hours	0.8 hours

Note that the largest increase in availability – from 22 hours of downtime to 1.6 hours of downtime per year – is the result of moving from a Tier II to a Tier III data center. It is not a coincidence that this increase in availability occurs simultaneously with the introduction of concurrent maintainability. A good data center design will permit concurrent maintenance of power and cooling system components.

COMMISSIONING

The best designed facility is no better than the implementation of the design. The commissioning process is important in order to verify the implementation. Commissioning is the comprehensive startup and testing of the equipment by qualified technicians. The formal acceptance process is required before the facility can be certified for use. This process ensures that site-specific training has been completed and accurate as-built documentation has been delivered. The formal commissioning process starts during the design phase to ensure design intent and continues through factory acceptance tests, field progress inspections, functional performance tests and integrated systems tests.

DATA CENTER ASSESSMENTS

In a data center that has already been built, a data center assessment is recommended as part of establishing a formal maintenance plan. A data center assessment is an investigative report focusing on power and cooling systems. It provides a critical assessment of existing power and cooling strategies. The assessment can improve data center performance and often exposes vulnerabilities within existing systems. In addition, it establishes an important benchmark for existing systems.

The power assessment assesses the overall status of the power infrastructure and can include the following:

- Power systems capacity analysis
  - Identification and analysis of all power systems, including:
    - Entrance switchgear
    - Distribution switchgear
    - UPS
    - Generator
    - ATS
    - PDU
    - Rack-PDU
    - Load panels & circuit breakers
  - Identification of capacity of all power systems (voltage, amperage, phase)
  - Measurement of the instantaneous and/or trending of all power systems (voltage, amperage, phase)
  - Comparison of measured load versus the capacity of all power systems
- Load bank testing
- Circuit breaker analysis
  - Short-circuit coordination
  - Trip point testing and setting
- Thermograph analysis
  - Identification and analysis of all critical systems, including:
    - Entrance switchgear
    - Distribution switchgear
    - UPS
    - Generator
    - ATS
    - PDU
    - Rack-PDU
    - Load panels & circuit breakers
    - CRAC/CRAH

        - Heat rejection equipment
        - Chillers
        - Pumps
- Availability assessment
    - Single point of failure analysis to assess redundancy
- Verification of one-line drawing (or creating a one-line drawing if one does not exist)
- Operations and maintenance assessment
    - Verification of documentation and records
    - Documentation of all processes and procedures
- Energy usage analysis
    - PUE/DCiE documentation and analysis
    - Recommendations to maximize efficiency and energy usage

The cooling assessment evaluates the cooling infrastructure and can include the following:

- Cooling systems capacity analysis
    - Identification and analysis of all cooling systems, including:
        - CRAC/CRAH
        - Condenser/fluid coolers
        - Chillers
        - Cooling towers
        - Pumps
    - Identification of capacity of all cooling systems (temperature, humidity, flow, pressure, etc.)
    - Measurement of the instantaneous and/or trending of all cooling systems (temperature, humidity, flow, pressure, etc.)
    - Comparison of measured load versus the capacity of all cooling systems
- Computational fluid dynamic (CFD) modeling
    - 3-D modeling of architectural elements and equipment
    - Model all load and air conditioner equipment
    - Spot measurement of all airflow, temperature, and humidity conditions
    - Baseline model analysis of airflow for existing conditions
    - Re-design analysis
    - Failure condition analysis
- Availability assessment
    - Single point of failure analysis to assess redundancy
    - Cooling systems failure analysis (does as part of CFD analysis)
- Verification of one-line drawing (or creating a one-line drawing if one does not exist)
- Operations and maintenance assessment
    - Verification of documentation and records
    - Documentation of all processes and procedures
    - Optimization recommendations for control systems operations
- Energy usage analysis
    - PUE/DCiE documentation and analysis
    - Recommendations to maximize efficiency and energy usage

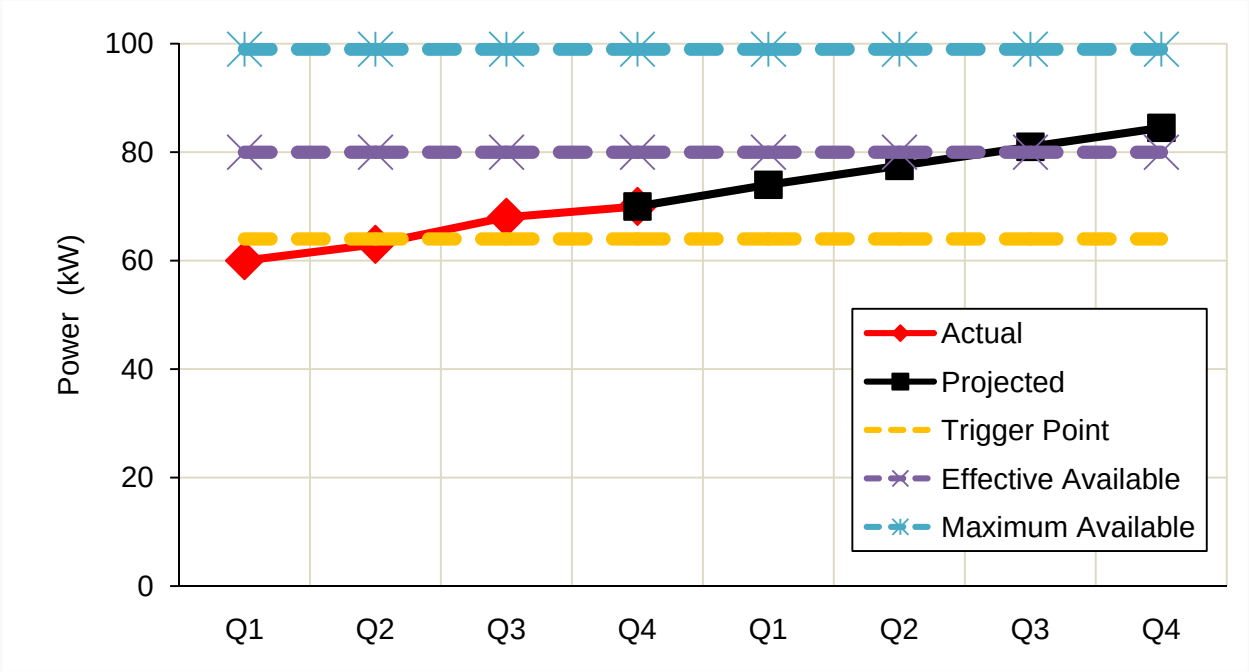
RELIABLE COMPONENTS

The overall data center reliability is only as good as the systems which make it up. It is important to select reliable components for use in the data center. In selecting equipment, look for high field-documented MTBF (mean time between failures) values. The systems should be fault tolerant, designed to minimize single points of failure and having the ability to handle failure of individual components without affecting the functionality of the systems themselves.

REAL-TIME MONITORING

Real-time monitoring is an important component of availability. Often the largest component in the mean time between failures (MTBF) is the time to recognize that a component or system has failed. Real-time monitoring greatly reduces this time. In addition, by being able to monitor many data points from many systems, monitoring can often correlate minor alarms that might be a pre-cursor to more serious issues. Taking appropriate action when a rack power distribution unit sends an alarm for current above the warning level, for example, can prevent system downtime.

Real-time monitoring also provides valuable information for use in capacity planning.



Effective available power is typically a 20% de-rating of the maximum level and represents the highest effective useable power usage for any power carrying equipment to maintain an adequate buffer.

The trigger point is typically 20% below the effective rating and represents the point at which an upgrade path must be clearly defined and implemented.

PREVENTIVE MAINTENANCE

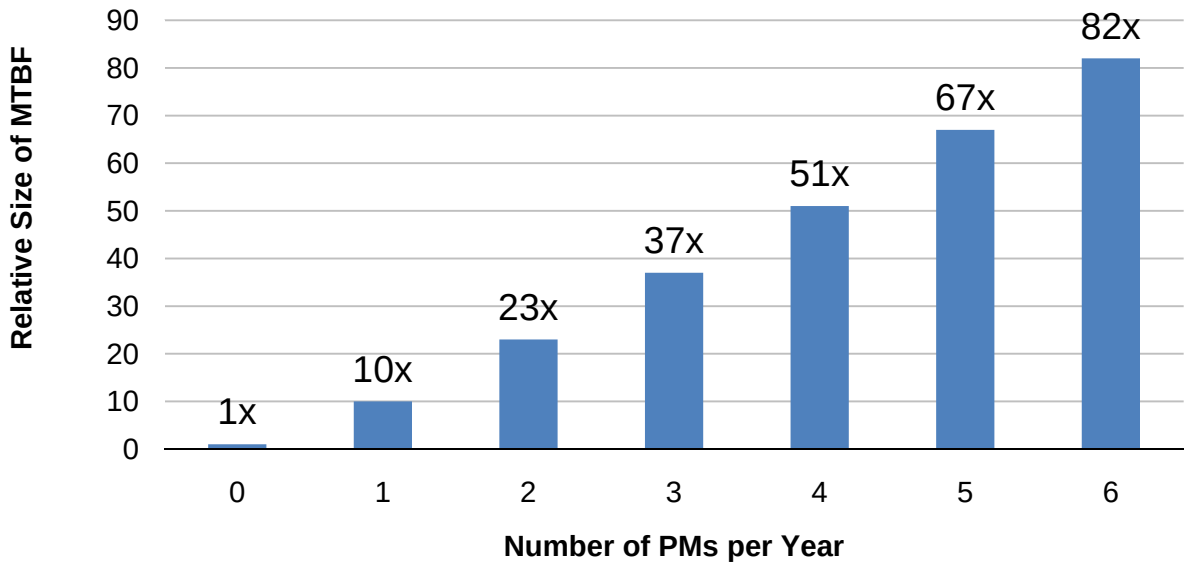
Preventive maintenance involves the inspection of equipment to detect potential failures before they occur. It is intended to prevent or reduce unplanned maintenance. It is analogous to regular check-ups with a doctor rather to help avoid an unplanned visit to the emergency room.

Preventive maintenance might include the following actions:

- Replacement of parts
- Cleaning of filters
- Lubrication of mechanical systems
- Firmware updates
- Measurement of key performance indicators

Preventive maintenance provides several important benefits. First, it can improve system performance. Trained service personnel can install the latest firmware, calibrate system parameters and clean and service the system to ensure maximum performance. Often, they can also make recommendations on improving system performance or energy efficiency.

Second, preventive maintenance can reduce unplanned downtime. Emerson Network Power analyzed data covering 185 million operating hours for more than 5,000 three-phase UPSs. They found that the MTBF for units that received two PM service events a year was 23 times higher than a unit with no PM service events.



Liebert – *The Effect of Regular, Skilled Preventive Maintenance on Critical Power System Reliability*

Just about everything in the data center needs regular maintenance --- including the data center itself.

■ PDU	Connections, meters, settings, firmware
■ Switchgear	Connections, circuit breakers settings, meters
■ Transformer	Connections
■ Air and water distribution systems	Valves, seals, piping internal densities, meters
■ CRAC/CRAH	Belts, air filters, piping connections, valves, seals, compressor, fan motors, filters, pumps, coils
■ UPS	Connections, fans, filters, capacitors, batteries, electronics boards, firmware
■ Humidifier	Drain, filter, plugs, water processor
■ ATS	Switch components, firmware, connections
■ Batteries (wet cell and/or VRLA)	Connections, electrolyte levels, temperature
■ Chillers	Oil pressure, levels, gauges, settings
■ Generator	Fuel levels, fuel filter, oil filter, hoses, belts, coolant, water pump, connections, alternator bearings, main breaker, fans, batteries, meters, settings
■ Computer room	Thermography, CFD, cleaning

DEVELOPING A MAINTENANCE PLAN

DEFINING THE OBJECTIVES

As a first step in developing a data center maintenance plan, it is important to define the objectives of the plan. This is typically done by answering the following questions:

- **When will the preventive maintenance be performed?**

  Performing preventive maintenance (PM) at night or on weekends or holidays is no longer the rule. These PMs are more expensive, will likely be performed by technicians that are less alert due to the odd or longer hours, and increase the probability of errors without having your most qualified people there to resolve them.

  It is important to plan around seasonal schedules, however. An online retailer, for example, would likely want to avoid doing preventive maintenance during the busy holiday season. It is also wise to avoid periods of high temperatures or the possibility of storms.

- **Which spare parts are critical and will kept on site?**

  Is it necessary to keep spare parts on site? If so, how will these parts be managed? What security needs to be provided for the parts?

- **What maintenance will be done by in-house staff?**

  The answer to this question is highly dependent on several factors: the complexity of the equipment and data center architecture, the availability of user-replaceable components, and the knowledge of the data center staff. Another important factor is the available access to manufacturer or third party support for tasks beyond the scope or ability of the internal staff.

  The advantage of the internal staff is that they can respond quickly to problems. The potential disadvantages are their lack of expertise and parts to resolve the issues.

- **What are the internal staff training requirements?**

  If the internal staff is going to perform some or all of the maintenance in the data center, it is imperative that they have the proper training on all of the equipment they are to maintain. Much of this equipment can be very dangerous, even deadly, without the proper training, tools and parts required for safe and effective maintenance.

- **What maintenance will be done by contractors and vendors?**

  The primary options for maintenance (outside of using internal staff) are manufacturers and authorized third party maintenance providers.

  - Manufacturers
    - Pros
      - Usually have stock of spare parts
      - Strong product knowledge
      - Ready access to latest upgrades and documentation
      - Personnel are factory trained/certified
    - Cons
      - More expensive
      - May not have local support
  - Third Party Maintenance Providers
    - Pros
      - Technicians can work on multiple products (often across multiple manufacturers), making it easier to coordinate PMs
      - May be able to offer 2 hour response
      - May cover areas manufacturer doesn't cover
      - Usually less expensive
    - Cons
      - May not have latest training updates
      - May not have ready access to all parts

- **Will condition-based maintenance be used?**

  As a supplement to calendar-based maintenance, condition-based maintenance uses key performance indicators to determine when PM needs to be performed. This is analogous to changing the oil in your automobile, which is changed every 6 months or 5,000 miles. The 6 months is calendar-based while the 5,000 miles is condition-based. Condition-based data that might trigger a PM for data center equipment might include the following:

  - Alarms from monitoring system
  - Equipment age
  - Abnormal events
  - Vibration, noise or temperature measurements
  - Run-time
  - Number of UPS battery discharges

  Condition-based measurements can be automatic (through a monitoring system) or through regularly scheduled manual measurements.

GATHER THE EQUIPMENT DATA

Before the data center equipment can be properly maintained, it is important to have a full record of all equipment to be maintained. All equipment should be named and labeled. There are two levels of equipment data which should be collected.

Basic Equipment Data

- Manufacturer
- Model
- Serial Number
- System Owner
- Date of Manufacture/Installation
- Electrical Power Requirements
- Capacity – Output Load, Cooling Output, etc.
- Parts Required – belts, fans, bearings, filters, etc.
- PM Provider
- Last PM date

Supplemental Equipment Data

- Design and shop drawings
- Installation, operation and maintenance manuals
- Equipment or product submittals

DEFINE ROLES AT SYSTEM, SUB-SYSTEM OR TASK LEVEL

The next step in the development of a preventive maintenance plan is to define roles for each piece of equipment. These roles may be at the system, sub-system or task level. There may be multiple roles assigned for a single piece of equipment. For example, the manufacturer may be assigned the role of PM provider for annual UPS maintenance. A third-party maintenance provider may be assigned the role of quarterly maintenance on the UPS. Internal staff may be assigned the role of daily or weekly inspections of the UPS. The roles may be assigned based on expertise, training, availability of parts and tools or cost.

If internal staff is to be used to perform some of the preventive maintenance tasks, a labor-needs analysis can be used to determine what level of staffing is required. This analysis is fairly straight-forward. First, a list of all equipment to be maintained is listed. For each piece of equipment, estimate the annual PM hours that are required for each unit. To determine the total number of hours required for each equipment type, simply multiple the number of hours for each unit by the number of units to be maintained. Total the hours to determine the total number of internal staff required.

When calculating the number of staff required, don't forget to include time required to maintain the maintenance records database and any time for daily inspections of the data center.

The following chart is an example of a simple labor-needs analysis:

Equipment	Annual PM Hours/Unit	Number of Units	Hours
Air Handler	38	20	760
UPS	20	4	80
PDU	24	16	384
CRAC	40	6	240
Cooling Tower	74	1	74
Daily Inspections	365	NA	365
Records Maintenance	100	NA	100
Total			**2003**

CHOOSE A CMMS

Preventive maintenance is vital to ensuring data center availability, yet its management is often relegated to spreadsheets and paper-based systems. There are multiple issues with using manual systems:

- Critical maintenance is overlooked because someone didn't remember to schedule the maintenance or the spare parts, tools or personnel were not available to properly perform the required tasks
- Don't allow you to estimate and track maintenance costs
- Can't track recurring minor problems to pinpoint those that may lead to much more critical issues over time
- Don't generate work orders with details needed to properly perform preventive maintenance
- Can't track real-time conditions to automatically generate break-fix work order

In order to address the drawbacks with the use of manual systems, a new class of computer application was developed. Computerized Maintenance Management Systems (CMMS) systems typically provide a wide range of functionality, including the following:

- Asset management
- Inventory control
- Preventive maintenance management including step-by-step instructions, safety considerations, a checklist of tasks to be performed, and a list of parts, tools and other special requirements
- Scheduling of PM jobs based on date or conditions
- Work orders
- Detailed reporting of maintenance data

The use of a CMMS system will greatly simplify the complex task of managing the maintenance in the data center. The general steps in successfully using a CMMS are as follows:

- Assign an owner of the CMMS

  It is important to have an owner of the system that will be responsible for administrative functions such as adding users and managing system tables.

- Select the CMMS functions you will use

  CMMS systems can provide a number of functions, but it is not necessary to use all of them. Select the functions that will best help in managing the data center.

- Train the staff on using the CMMS

  In order to get the best usage from the CMMS system, take the time to properly train the staff that will be using the application.

- Enter the equipment data into the CMMS database

  Enter the equipment data that you previously collected into the CMMS database with as much detail as you can provide, including documents, drawings, and so on.

- Enter the PM schedules into the CMMS database

  Define the tasks that you want to perform for each system or sub-system. Determine the schedule for the various tasks (quarterly, annually, etc.).

- CMMS will calculate the next PM schedule for each piece of equipment

  Once the equipment and PM schedules have been entered, the CMMS system will then update the schedules accordingly as the tasks are performed, ensuring that no future maintenance is inadvertently overlooked.

Create and Post an Annual PM Calendar

Posting an annual PM calendar will keep everyone alerted to any maintenance that is to be performed, when it is to be performed and by whom. This will allow proper coordination between internal staff, manufacturers and third party maintenance providers to ensure preventive maintenance runs smoothly.

Evaluate Maintenance Plan on a Regular Basis

As with any process or plan, it is important to review the results on a regular basis to ensure that the plan is operating as designed. If not, a regular evaluation is a good time to make whatever adjustments deemed necessary for the plan to operate more effectively.

SUMMARY

Maximizing availability in the data center involves the following components:

- Designing for functionality, redundancy and maintainability
- Selecting components with high field-documented MTBF
- Real-time monitoring to quickly spot problems and to predict future problems
- Preventive maintenance

A maintenance management plan involves the following steps:

- Defining the Objectives
- Gather the Equipment Data
- Define Roles at System, Sub-system or Task Level
- Choose a CMMS
- Create and Post an Annual PM Calendar
- Evaluate Maintenance Plan on a Regular Basis

About the Author

Dave Cole is the Manager of Data Center Management & Education Services at PTS Data Center Solutions, Inc. (PTS). Dave is a recognized industry leader in the field of data center monitoring and management technologies.

Prior to joining PTS Data Center Solutions, Dave Cole served as the president of the real-time monitoring division of Aperture Technologies, now a part of Emerson Network Power. He was the founder, president and senior software architect for The Advantage Group, a software development company focused on data center management software before the company was acquired by Aperture Technologies. He has also held positions as a Senior Software Engineer at Emerson Electric, Information Technology Manager at Contel, Director of Research and Development at Systems Enhancement Corporation (later acquired by APC) and Director of Software Engineering at Tripp Lite.

He has extensive experience in software development, data center management, and device monitoring and control.

He is a Certified Data Centre Professional through ICOR (The International Consortium for Organizational Resilience), a Microsoft Certified Professional Systems Engineer and is certified in ITIL v3 through OGC.

He has presented at Data Center Dynamics, Data Center World, AFCOM, and other data center forums in the United States and Europe and has had articles on data center monitoring and management published in multiple publications.

About PTS Data Center Solutions

Experts for Your Always Available Data Center

PTS Data Center Solutions specializes in the business strategy, planning, designing, engineering, constructing, commissioning, implementing, maintaining, and managing of data center and computer room environments from both the facility and IT perspectives.

Founded in 1998, PTS is a consulting, design/engineering, and construction firm providing turnkey solutions, and offering a broad range of data center, computer room, and technical space project experience. PTS employs industry best practices in integrating proven, 'best-of-breed', critical infrastructure technologies that result in always available, scalable, redundant, fault-tolerant, manageable, and maintainable mission critical environments.

Integrated Data Center Facility and IT Expertise

With a proven process for understanding and addressing client needs as well as integrated facilities and IT experience and expertise, PTS has a unique vantage point for executing data center, computer room, and network operations center projects.

In every engagement, PTS applies a disciplined, consultative approach to systematically survey and assess the situation and then develop effective plans for seizing opportunities and overcoming obstacles. And, PTS offers a full complement of services—from business strategy and planning to facilities engineering to IT design and implementation—to help transform those plans into reality.

From our corporate headquarters in Franklin Lakes, New Jersey, and our office in Orange County, California, PTS works to fulfill our mission of creating satisfied customers by emphasizing planning and pre-construction services to provide the optimal people, process, and technology solution to meet our clients' needs and results in an early and accurate alignment between scope, schedule, and budget.

For more information, contact PTS at 1-866-PTS-DCS1 / 1-866-787-3271 or visit PTS online at www.PTSdcs.com.