Manufacturing Insights
An IDC Company

Configuration-Based Maintenance Repair and Overhaul of Complex Equipment

WHITE PAPER

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MANUFACTURING INSIGHTS OPINION

Maintenance of capital equipment is a critical business activity. Technology complexity, resource limitations, regulations, and, above all, equipment uptime and customer satisfaction make maintenance, repair, and overhaul (MRO) a significant challenge for manufacturers, asset owners, and those tasked with maintaining the assets and ensuring a high level of productivity.

In an economy dominated by price pressures and shrinking margins, asset owners and maintainers seek ways to optimize the use of resources and lower the cost of maintenance activities, with minimal negative impact on equipment productivity.

Accurate product configuration and maintenance history help mature maintenance organizations to excel in managing equipment complexity and optimize MRO operation.

Maintenance organizations that excel in managing equipment complexity and optimize MRO operation rely on accurate product configuration and maintenance history as a vital facility to manage assets, optimize maintenance schedules, streamline operations, and ensure compliance with requirements.

SITUATION OVERVIEW

MRO Business Drivers

Manufacturers of complex capital equipment used to enjoy brand and market share protection granted by the proprietary complex technologies they developed and owned. They made large investments in technology intellectual property to gain and protect market share and create barriers for entry by the competition.

This protection has started to erode in the last decade. Barriers to entry to new technologies are getting lower not only in the industrial world, but also in low-cost regions, and many manufacturers can no longer compete solely on the basis of features and functions and must provide higher product quality and value for the entire life of the product at lower costs.

Shrinking margins force manufacturers to look for additional sources for product revenue. Forward-thinking organizations use after-sales service to generate additional service revenue and create a "pull" for additional product sales. Many customer service organizations that used to operate as cost centers are evaluated on their P&L now.

Equipment owners need to squeeze more from their investment and require longer life and a higher level of uptime. They have higher levels of expectations from their service providers, demanding reduced turnaround time, higher first-time fix rates, and longer intervals between scheduled service events.

Higher customer expectations and business pressures underscore the need to excel in the delivery of after-sales service as a customer-facing activity that serves a critical role in ensuring customer satisfaction and building customer loyalty. Customers are enforcing these expectations and calling equipment and service providers to task by demanding contractual agreements based on service-level contracts (SLC) and performance-based logistics (PBL).

These pressures have brought about a change in the business relationships between asset owners and service providers, whether in-house, original equipment manufacturers (OEMs), or third-party maintenance (TPM) providers. The contractual obligation between customers and service providers has moved from response time and costs to performance-based service-level agreements that focus on equipment utilization, whether it is a manufacturing plant, energy plant, aircraft, ship, or major subsystem. Service organizations need to optimize resource utilization, delivering the right part and the right procedure to the right person at the right time throughout the service value chain.

Yet another important consideration in MRO is the need to comply with regulations that govern the maintenance and operation of equipment. In some industries, such as aviation, medical equipment, and power plants, all configuration changes, faults, and maintenance actions must be recorded to ensure and prove regulatory compliance. In the case of the aviation industry, maintenance activities are carried out by thousands of workers in multiple dispersed locations. Without a historical maintenance record, certification for use can be withheld, greatly diminishing the value and increasing the total cost of ownership of the asset.

Business Pain Points: Challenges in Maintaining Complex Assets

Maintenance of complex capital equipment requires the coordination of maintenance activities needed by manufacturers and equipment owners and users. Ensuring that all the necessary maintenance tasks are performed on time, but only the appropriate work, is a difficult task.

Increased Complexity

The number of electronically controlled components and software content in complex capital equipment continues to increase at a fast pace. Although these technologies improve functionality and reliability, they also make equipment failure diagnostic and repair much more challenging, especially for a generation of mechanics and technicians that have come to the business before these technologies became prevalent.

Multiple Configurations

Many products and equipment on the market are available in a variety of configurations and installed options. Manufacturers, needing to meet customer needs and reach new, sometimes very narrow, markets, offer a high degree of customization and localization of products and provide customers with user- and field-installed options. As software-controlled products make these options available at very low incremental costs, manufacturers quickly offer them, unaware of the impact they might have on downstream MRO activities.

Another reason for the proliferation of product variants in equipment with long service life, such as aircraft, ships, and power plants, is the technology evolution and design improvements that trigger many upgrades and changes throughout the asset's long service life. To make matters worse, not all upgrades are adopted and implemented consistently, creating discrepancies between the recommended configuration and deployed equipment, a fact that can go undiscovered for a long time, usually until an equipment failure triggers a service call.

When performing a maintenance task, a service technician needs to know both the as-built information, the associated detailed manufacturing data, and the as-maintained configuration so he can obtain relevant, up-to-date, and approved procedures, spare parts, instructions, and best practices that are specific to that configuration.

The Knowledge Gap

Several technological and demographic trends are slowly converging to create a challenge not yet recognized by many MRO organizations.

- Improved product reliability leads to attrition in technicians' experience and decreases their efficiency.

- Aging workforce with many years of experience that was never captured, documented, and formalized is leaving the organization, creating knowledge attrition that is hard to restore.

- Configuration-rich installed base, made up of many one-off instances, means that a service technician may see very few of each instance.

Forward-thinking MRO organizations must take measures to manage and reduce the knowledge gap — the gap between the information and knowledge required to maintain an asset that the technician or service organization actually has.

CONFIGURATION-DRIVEN MRO

From the discussion above, it is evident that maintenance practices that treat the entire installed base as a monolithic entity, or, conversely, that focus on the individual components and subsystems cannot deliver an optimal level of performance. Effective maintenance must recognize the unique configuration of each asset in the installed base and consider the maintenance history and performance requirement of each in delivering optimal maintenance.

Maintenance Planning

In an economy of price pressures and shrinking margins, asset owners and maintainers must lower the cost of maintenance activities with minimal impact on equipment productivity. They seek ways to lengthen maintenance cycles, optimize use of resources, and ensure that all required maintenance tasks are performed on time and according to regulations, best practices, and conditions.

Precise and up-to-date asset configuration and maintenance history offer forward-thinking maintenance organizations multiple opportunities to improve and lean their maintenance operation.

Resource Optimization

The fire-fighting mentality of too many service organizations leads to assigning first-available rather than best-fit resources. Configuration information and longer-term planning enable service organizations to allocate the most suitable resources — maintenance personnel and MRO facilities — for maintenance tasks.

Maintenance Optimization

Large and diverse installed bases benefit from maintenance activities that are highly optimized for each individual asset. Accurate information assists in establishing maintenance optimized for the specific requirements of each asset based on as-maintained configuration, reliability, and operation history and performance.

Inventory Optimization

Direct and indirect inventory costs can quickly wipe out service revenue margins. Service organizations, logisticians, and spare part managers are often too quick to reduce inventories and hurt service-level agreements, uptime, and customer satisfaction.

Combining as-maintained configuration information and failure history helps forward-thinking MRO organizations create predictive models to optimize inventory operation while maintaining service-level agreements, equipment uptime, and customer satisfaction. Tracking usage of parts in inventory against their life expectancy permits optimum utilization of service parts and inventory planning to meet maintenance cycles and requirements.

Service-Level Optimization

Sophisticated equipment owners demand that maintenance contracts be based on actual asset performance levels, such as uptime and productivity level; dispatching a technician to "stop the clock" is no longer adequate to meet the terms of the service-level agreement. Maintenance organizations must have an accurate account of asset configurations and associated failure rate for capacity planning and cost estimation, and to guide them in negotiating service agreements.

Maintenance Delivery

Having to increase uptime and reduce operating costs, maintenance organizations must take steps to streamline and improve their operations. One of the more challenging elements of this process improvement effort is improving the accuracy and efficacy of servicing a piece of equipment.

Service Information

Many maintenance organizations suffer from an explosion of technical information that has accumulated over the useful life of products, much of which may have become outdated or obsolete. Service technicians must be able to identify the service information that pertains to the equipment to be serviced and be assured that this information represents the complete, accurate, and up-to-date information needed to perform the required maintenance task. A configuration-driven knowledge framework ensures the delivery of service information in the proper context of the asset under maintenance.

Diagnostics

Perhaps the most perplexing challenge facing the service organization is the need to track, analyze, diagnose, and repair the elusive problems created by unique equipment configurations. Frequently, certain failures occur only under a limited set of configurations. Maintenance technicians can be far more effective when they have access to a repository of failure modes and repair histories of similar configurations, and utilize the authorized best practices that are optimized for the configuration and the repair task at hand.

Most maintenance organizations track equipment repair history to help in maintenance planning and designing effective troubleshooting strategies. Many mature organizations also track each part's failure and repair history throughout its life so that they can detect marginally operating parts and either limit their use to only certain configurations and operational requirements or, if a part continues to fail, decommission or overhaul it before its expected end of life.

Workflow

Configuration-driven maintenance procedures and workflow that are optimized for each task promote maintenance efficiency and reduce downtime and costs. Additionally, they ensure compliance with internal and regulatory policies and contribute to a technician's safety.

Maintenance Optimization

Many maintenance delivery organizations schedule routine maintenance tasks based on predefined rigid schedules. Reliability-centered maintenance (RCM) practices are based on a priori knowledge of mean time between failures (MTBF) and schedule routine maintenance to occur before a failure becomes statistically inevitable.

To make RCM effective and to guarantee the safety and readiness of mission-critical equipment, a routine maintenance schedule tends to be very conservative, which leads to waste of resources. Sophisticated maintenance planners do not use a single monolithic schedule. Instead, they use configuration information to adjust the maintenance schedule according to asset-specific MTBF and operating history to optimize scheduled maintenance tasks while still maintaining compliance, safety, and operational readiness.

Forward-thinking manufacturers and equipment owners find that they can further improve uptime and reduce maintenance costs by performing maintenance only when there is an objective and accurate evidence of need, as inferred from the physical condition of the equipment. Developing a reliable condition-based maintenance (CBM) system is predicated upon having good visibility to configuration information and a detailed history of all equipment of similar configuration.

CONCLUSION

Maintenance of capital equipment is a business-critical activity for manufacturers, asset owners, and maintenance organizations that seek to lower the cost of maintenance activities with minimal impact on equipment productivity, total cost of ownership, and customer loyalty.

Configuration-driven data management and maintenance processes are key capabilities exploited by advanced maintenance organizations to achieve lean maintenance operations and create an evidence-based foundation for process and product improvement. Having a single source for that configuration definition and related data greatly improves data integrity, service quality, and efficiency and ensures collaboration throughout the service value chain.

CASE STUDIES

The Royal Australian Navy

The Royal Australian Navy (RAN) maintains a very large and eclectic mix of equipment, including ships and submarines, weapon systems, and support equipment. To obtain a higher level of readiness, the RAN must ensure that all equipment is configured, maintained, and upgraded in a consistent way.

"Configuration Management is at the core of the Maritime Systems Division business model and Teamcenter provides the key capability in the area for the RAN."

Captain A. S., Royal Australian Navy

Managing a large naval fleet, some of it 10 years and older, that has undergone several cycles of retrofitting and upgrade by scores of suppliers and subcontractor is a significant challenge for both maintainers and logisticians.

The RAN uses a centralized shore-based system to manage all the information about the fleet's assets. UGS' Teamcenter is the navy's single system of record that maintains the configurations, technical information and drawings, maintenance history and plans. Teamcenter drives all maintenance and upgrade activities and serves as the change authority for the fleet and vendors.

The RAN employs ship-based tools to manage maintenance tasks. Teamcenter, as the RAN Configuration Management tool, provides the ship-based maintenance tools and the approved standard maintenance activities, including scheduled maintenance tasks, maintenance triggers, and standardized maintenance procedures. Teamcenter communicates all standard activities and pertinent documentation to the ship-based maintenance execution system, ensuring that the crew performs all necessary activities based on the most recent information and approved best practices. Upon task completion, information is sent back to Teamcenter to reflect the work performed and any configuration changes.

This centralized governance allows a single repository of all fleet configuration, maintenance history, and maintenance planning, creating a single, consistent, and accurate context for maintenance planning and readiness assessment, across all functional elements of the logistics organization.

As a result, the RAN is able to improve mission readiness and resource utilization:

- Standardization of all maintenance operations is based on authorized best practices.
- Maintenance crews perform only required tasks and only when and as needed.
- Shorter maintenance time and optimized resource allocation improve equipment uptime and add capacity to handle unscheduled maintenance events.

Hendrick Motorsports

Hendrick Motorsports is not a mainstream manufacturer or maintenance organization, nor does it maintain massive fleets like the Royal Australian Navy. Hendrick builds and supports race engines and race car platforms that are used by race teams around the country. While the car racing industry may be considered a narrow and specialized niche, designers and maintenance crews face product life-cycle issues and maintenance challenges that, in many respects, not only are very similar to other industries but also occur under harsher conditions and in a much accelerated fashion, putting further burden on owners, engineers, and maintainers.

Race cars are not maintained in the same way as most other asset types. To achieve maximum performance, engines are operated at full capacity and then remanufactured and overhauled based on each engine's configuration and operating history since its last overhaul. Hendrick employs UGS' Teamcenter configuration management to maintain a complete view of engines, configurations, and performance and test history and optimize the remanufacturing schedule to maximize resource utilization and provide best performance to the race teams. Moreover, Hendrick relies on this comprehensive view to determine if a problem identified in a certain engine configuration may show up in other instances and to correct the problem before it occurs in other engines.

"We must avoid a failure during a race at any cost. We must have complete information about the exact configuration and history of each engine."

Dir. of Engineering, Hendrick Motorsports

Hendrick is focused on maximizing the performance of race engines and cars. Hendrick engineers depend on historical performance data from races and test cells, which they correlate with information about engines, car configurations, and racetrack characterization to improve performance predictability and optimize each car configuration for a specific race and racetrack conditions. These changes can occur at a very rapid rate as a response to data obtained during a race and, depending on the nature of the change, may have ramifications concerning other cars or may be a one-time short-lived incident. There is no second chance for any given race. Performance must be there race day.

The race car industry is highly regulated, and the rules change often. Hendrick must ensure that as it strives to improve engine designs and maintenance practices to achieve maximum performance during a race, it remains in compliance with the continuously changing regulations.

With so many variables and constraints and frequent last-minute configuration changes, Hendrick faces a formidable challenge. Teamcenter configuration management helps Hendrick keep them in sync. The centralized approach ensures that Hendrick makes the best use of resources, knowledge, and expertise to maximize and stabilize race performance, remove engine-to-engine performance variations, and provide higher value to its customers.

"Configuration-based maintenance-driven BOM (bill of material) and cycle time is much more formal and disciplined than just by part numbers."

Dir. of Engineering, Hendrick Motorsports

METHODOLOGY

This white paper was sponsored by UGS. The case studies provided in this white paper are based on actual organizations that are currently using a UGS solution in their maintenance, repair, and overhaul operation. Each case study company participated in a formal, structured interview with a Manufacturing Insights MRO analyst. Manufacturing Insights also performed extensive secondary research in the course of preparing this white paper.

Manufacturing Insights believes in the organizational value and the business benefits of a configuration-centric MRO solution. However, this paper is not intended to specifically recommend the UGS solution; rather, it points out the strengths of this particular solution when applied in a complex maintenance and repair environment, as experienced by the case study companies.