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Knowledge-centric MRO transformation

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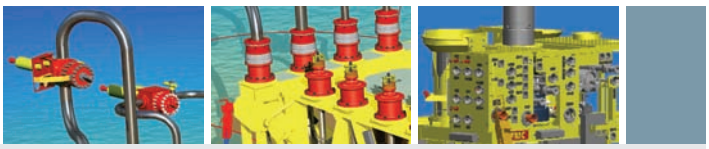
white paper



Military OEMs must transform their MRO operations to a knowledge-centric, digital environment in order to achieve performance-based metrics and optimize fleet availability while managing total cost of ownership. This requires a new approach that integrates system configurations with their operational histories in a single source of synchronized information, providing a comprehensive, lifelong record that is accessible to authorized users at the time of need.

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Answers for industry.

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Table of contents

Executive summary

Over the extended life of a military system or platform, the sustainment – or maintenance, repair and overhaul (MRO) – phase represents 60-80 percent of the entire system lifecycle. Research by CSC Consulting Group shows that this phase can represent "three to eight times the production value of an aerospace and defense (A&D) product, and provide valuable insights into the operational functionality required of future products."[1] Military OEMs are being asked to assume responsibility for the total care of these systems/platforms, even as cost pressures are increasing and resources are limited.

Up to now, the responsibility for logistics and sustainment has been spread across the globe through a vast network of service and support organizations. This environment creates significant challenges in resource allocation, information management and service management. Current processes are predominantly manual and paper-based, resulting in unnecessary delays and making it extremely difficult to optimize fleet availability. In order to meet performance-based service commitments, customer service and product support executives must take a more disciplined, automated approach to MRO.

Military OEMs' primary barriers to effective maintenance, repair and overhaul operations include:

- *Limited connectivity to OEMs and engineering data*
- *Lack of integrated data management systems that support the MRO process*
- *Inability to link the operational performance of a part, spare, system or platform to its bill of material*
- *Insufficient ability to optimize maintenance planning and inventory*
- *Wasted time and effort due to an inability to work collaboratively and manage change in a complex environment*
- *Difficulty of managing maintenance execution for continuous improvement*

To remove these barriers, military OEMs are adopting information technology – and in particular product lifecycle management (PLM) solutions – to establish a seamless digital, knowledge-centric environment for MRO. Widely used by OEMs in product development, PLM offers capabilities using familiar tools that can greatly benefit MRO organizations. With these tools, customer service and product support executives can transform their operations, resulting in:

- *Reduced cost and faster MRO cycle time*
- *Improved system/platform availability*
- *Increased productivity of direct and indirect forces*
- *Improved use of working capital*
- *Assured compliance, safety and airworthiness*
- *Demonstrated achievement of service and performance-based contracts*

[1] *Aerospace and Defense Information Technology Survey*, CSC Consulting Group, 2003.

Introduction

With increasing pressure to improve productivity in MRO operations, military OEMs need to reduce cycle time to an absolute minimum and return critical systems to operational status as quickly as possible. The ability to determine the current condition and configuration of a system, line-replaceable unit (LRU), or component as well as its required state when it leaves a facility is key to any process improvement. Equally important, military OEMs need to capture and manipulate accurate data about their MRO processes, performance and results and understand the impact of change over the entire product lifecycle.

The MRO business is highly complex, involving a large and diverse value chain. Aging fleets are expected to increase demand in MRO for military aircraft by 2 percent a year.[2] At the same time, military customers are demanding enforceable performance-based contracts and service level agreements, creating significant cost and resource-management pressures for OEMs.

Historically, logistics systems have not been incorporated into programs early in the lifecycle. Instead, military OEMs have used a broad array of program-specific logistic solutions and paper-based processes that focus on specific tasks or programs. None of these approaches effectively manages the entire logistics environment.

As customer service and product support executives strive to optimize their business, they struggle with significant barriers to improving fleet availability and reducing costs while maintaining safety and performance. For example:

- Access to information that is current, correct and comprehensive at any given moment is a fundamental requirement for military OEMs that want to increase performance while managing risk. Traditional manual, paper-based processes are not up to the task. They add complexity and waste to the process and result in costly delays.
- Adequate resources must be available to meet scheduled and unplanned service requirements. To ensure they can meet service commitments, OEMs typically over-invest by maintaining redundant inventory across the supply chain. This results in an inefficient use of working capital. Transport, wait time and other nonvalue-added activities extend the MRO cycle time significantly, keeping valuable assets in the depot longer than necessary.
- Information is hard to find. Direct and indirect forces spend up to 80 percent of their time searching for and verifying information. Build books that document service bulletins and change orders can rapidly get out of date. Since they physically travel with a system/platform as it moves through the depot, they are not accessible.
- The ability to analyze the service history and operational performance of a system/platform is extremely limited. Today, information on service events and operational performance is maintained on paper. The process of updating build books with the latest directives from the design authority is time consuming and error prone. Maintenance planners lack visibility into the life limits of a system, component or LRU, making it difficult to balance resources and optimize processes.
- Collaboration and information sharing among distributed teams and across disciplines is critical to the success of MRO optimization. Traditional build books and siloed applications make it extremely difficult to do this in a timely manner. Information often is locked away in people's heads or stored in multiple disparate systems.
- OEMs need better, more precise ways to capture data and demonstrate achievement of performance-based metrics.

[2] *Ready for Takeoff: An Overview of the Global Military MRO Market*, AeroStrategy LLC, 2006 MRO Conference, April 2005.

Customer service and product support executives must begin the process of transforming their paper-based records and processes to digital records and workflows. Technologies that are based on open standards and use familiar tools can provide a solid foundation for building a common digital environment through which engineering, logistics and service teams can collaborate regardless of where they work. Product and process information can be shared across boundaries and time zones, thereby ensuring that all MRO activities – from planning to materials and execution – are driven from a single, accurate definition of each system/platform.

Any digital solution that OEMs adopt must manage the product configuration and all its related information in a way that reflects design intent and functional requirements while supporting sustainment processes and workflows. A digital approach eliminates the delays and costly mistakes inherent in paper-based ledgers. With the proper authority, direct and indirect forces can enter changes to the bill of material (BOM), so that the most current data is always available. Authorized users at every stage of the process can input, access and probe this information in real time from their PCs or PDAs. Using standard browser technology and 3D visualization tools, unprecedented insights can be gained. Product, process and supply chain decisions can be based on accurate data and communicated more effectively across the MRO value chain.

This paper discusses fundamental MRO processes and illustrates how information technology, and PLM in particular, can help OEMs improve these processes in ways that let them comply with performance-based logistics goals. The following processes can be improved though the use of PLM.

Customer support

- Establish a standardized, enterprise-wide digital MRO environment
- Manage product and process data, knowledge and experience

Maintenance planning

- Optimize processes, procedures and inventory across facilities

Maintenance execution

- Generate accurate, visual work instructions
- Provide real-time, online information access and communication

Quality control and safety

- Track compliance across a system/platform's operational life

Sustaining engineering

- Accelerate and simplify upgrades and enhancements

Can you reduce cycle times and increase fleet availability to meet performance-based logistics goals?

It is becoming increasingly difficult to track and maintain the ebb and flow of the BOM across a system/platform's 50-year lifecycle, particularly as the service value chain becomes increasingly global and complex. Today's MRO environment is characterized by build books, ledgers and siloed systems at different stages of automation, reflecting the extended legacy of military systems/platforms under the OEM's control. Even the most modern aircraft lack a comprehensive, integrated knowledge management system that provides access to information in real time. To meet the requirements of performance-based contracts, all bases that touch and influence a system/platform's configuration must record what they do. This information must then be consolidated in the master log, which is physically sent along with the part, component, or subsystem to everyone who works on it.

This heterogeneous information environment creates huge inefficiencies that will only increase as MRO demand grows. In their efforts to streamline MRO operations and to return assets to a state of readiness as quickly as possible, customer service and product support executives face critical challenges:

- Significant time and effort is wasted on data search and retrieval. Changes recorded on paper as parts, components, subsystems, or systems that are repaired or overhauled cannot easily be linked to the BOM.
- There is no consistency among programs. Historically, records have been retained on the basis of their related model or program. This restricts an organization's ability to identify processes and procedures that can be optimized or automated; it also inhibits the organization from re-using a program's proven parts.
- It is not possible to capture best practices and lessons learned for continuous process improvement.

Manage global service data through a common digital environment

Customer service and product support executives must establish an automated, disciplined approach to MRO. This requires a standardized, enterprise-wide digital environment that can scale to support the service enterprise for fleets comprised of 6000 or more aircraft and 300-400 terabytes of data.

This kind of environment can be implemented through PLM solutions tailored to the MRO business. These solutions make it possible to effectively manage and share all product and process data, knowledge and experience across the value chain. Detailed information about each platform's LRU, parts and components – including service data coming from multiple sources inside and outside of the organization – can be tracked and accessed by authorized personnel from any location, using browser-based interfaces and familiar devices such as PDAs.

Service data can be validated automatically against OEM specifications and directives. When a system/platform enters a facility, management can compare the as-built to the as-maintained BOM to determine the necessary service actions and eliminate delays. This makes it possible to optimize resource allocation and increase throughput. By reducing the time required to process systems or subsystems, tear them down, complete the work, reassemble and test them, service organizations can return them to the proper state of readiness in less time, making it possible to meet their operational obligations with existing fleets.

Logistics configuration management closes the loop for the Royal Australian Navy

A fire aboard the Royal Australian Navy fuel tanker HMAS Westralia claimed the lives of four crew members in 1998. As a result, the Navy identified several areas for improvement in the way it approached product lifecycle management. This included acquiring a dedicated Navy-wide PLM solution and configuration management tool intended to address deficiencies in the change management process that contributed to the Westralia incident. Now, all of the Navy's ships have a product definition supported by a logistics support package.

According to Garry Russell, the project manager of the Navy's Configuration Management Tool Program, "The PLM solution and configuration management tool allow us to manage that definition through the entire life of the asset. At all times, the people on the ship understand what their ship looks like and how they should repair, operate and maintain it to sustain its maximum operational capability."

If a maintenance routine is not providing the expected results, a ship's crew can raise a problem report to the shore support organization through workflows implemented in the PLM solution. This well defined process ensures that a closed loop covers the full and continuous life of the ship.

How accurate are your maintenance and inventory forecasts across facilities?

Most MRO operations consist of isolated, localized teams that work for different entities. Many organizations manually track inventory and record changes to the BOM, making it difficult to know at any given time what parts are on site and what parts are needed for MRO. This makes it extremely challenging for maintenance planners to manage the flow of service events or to ensure that inventory is up-to-date and able to perform the service work coming through a facility.

Planners face significant challenges in their efforts to optimize processes, procedures and inventory because:

- Information is difficult to find. Lots of time is spent searching for and validating information. It is difficult to make decisions on how to respond to engineering change orders.
- Change management is a significant issue that affects not only inventory optimization but also service productivity. Process steps often are superseded by revisions or by new steps when a new part is required. Without an automated process to deal with these changes, the responsibility for ensuring that the correct parts are used is pushed to the factory floor.
- Redundant inventory is maintained across the supply chain to ensure that adequate resources are available to meet scheduled and unplanned service requirements. This approach ties up working capital and increases the risk that inventory will be obsolete.

Integrate the BOM with operating experience for accurate forecasts

When product configurations, or BOMs, are maintained electronically, data entry and retrieval can be streamlined. All service actions related to a subsystem, part, or component can be recorded automatically along with the BOM, which can be linked with both the as-built BOM and the operating experience of the system/platform. As a result, a snap shot of the BOM at any point in time will show a current, accurate configuration of each subsystem, LRU, or part that comes into the depot, as well as all actions that need to be performed on them.

For example, entering the serial number of a tail section automatically brings up all information associated with that subsystem, including serialized and non-serialized components or parts. This can include its physical and functional aspects, along with its associated maintenance history, airworthiness directives, change orders and operating experience. With real-time, online access to comprehensive inventory data, maintenance planners also know precisely what LRUs, spares and materials are available at each facility.

Given this comprehensive knowledge, management can forecast maintenance requirements based on what will be coming into any of their facilities at any point in time. Maintenance planners can create service plans and workflows based on specific requirements of a particular service event. Digital information can be mined and analyzed to evaluate workflows and identify the root cause of delays. MRO planning tools give planners the visibility they need into the service process to eliminate nonvalue-added tasks. These tools also help planners find ways to reduce the time required to complete tasks on the critical path without affecting service quality and system reliability. By minimizing nonvalue-added activity, planners are able to move a system/platform through the depot and return it to operational status in significantly less time.

What is PLM?

"Product lifecycle management is an integrated, information-driven approach to all aspects of a product's life – from its design inception through its manufacture, deployment and maintenance, culminating in its removal from service and final disposal."

University of Michigan, PLM Development Consortium

Are you maximizing the productivity of your direct and indirect forces?

The process of managing the execution of MRO operations has become increasingly complex as MRO processes and relationships have become more global. Information is often stored in disparate systems and maintained within geographically dispersed teams that work for diverse organizations. Communications rely heavily on manual, paper-based processes and log books that travel with the part, component, or LRU.

As a result, direct and indirect forces spend too much time looking for information and not enough time on process and quality improvements. Unnecessary transport, wait time and other nonvalue-added activities extend the MRO cycle time significantly, keeping valuable systems in the depot longer than necessary – as the following examples illustrate.

- Direct and indirect forces can spend as much as 80 percent of their time searching for and verifying information. Licensed mechanics responsible for performing maintenance or repairs waste valuable time searching for the information they need, and then validating that they have the correct instructions and materials for the job.
- Work instructions might not reflect the correct version of a part, component, or LRU. Since these instructions typically are created as spreadsheets, it is impossible for a mechanic to readily identify when incorrect parts have been delivered.
- Build books that document service bulletins and change orders can rapidly get out of date. Since these books physically travel with a product as it moves through the depot, they are not readily accessible.

Provide real-time access to product and process knowledge

In electronic form, the BOM can be associated with both the physical and functional representations of the part, subsystem, or system/platform. As a result, work instructions can include pictorial information on how to install or remove items, showing the physical arrangement of parts and subsystems. Assembly-disassembly procedures reflecting best practices for a particular subsystem, LRU, or component can be embedded in the software, thereby ensuring an optimal workflow for any given process or task. Since instructions and procedures are generated directly from the BOM, they reflect the most current configuration.

When the digital environment is extended to the complete service environment, work procedures can be synchronized across the entire value chain. Mechanics with proper authority can access technical data and documentation at the point of need, in real time. In this way, they can immediately verify that the part they are pulling from the bin matches the configuration and revision number of the system or subsystem they are maintaining.

At the same time, mechanics can document every action, decision, part serial number and other relevant information directly into required reports as they work. This eliminates manual records that introduce errors and delays while building a chronological record of the system or platform. It also creates an audit trail for compliance with customer and regulatory requirements.

Information transforms a mechanic's productivity

Imagine: The mechanic on the line receives complete work instructions that visually depict disassembly-assembly instructions based on the most current BOM for the component or system in question. The mechanic needs clarification and sends a query to the engineer using a PDA and gets an answer right away. Confident that the correct information is now available, the mechanic orders the parts specific to this system revision and begins the overhaul. The mechanic's order updates the supply chain, so inventory remains up-to-date. Every decision, step, test and result is captured electronically, including certification and sign-off. The mechanic is now ready to process the next job.

Can you verify compliance, safety and airworthiness?

Ultimately, OEMs are responsible for ensuring the integrity of all products under their control, including airworthiness, safety and compliance with design authority recommendations. Administrative engineers perform labor-intensive audits that compare recommended actions against records kept in various forms and disparate systems – or sometimes do not exist at all. Compliance officers must be able to present traceable records of all actions to government and FAA inspectors, documenting that proper procedures were followed and that the individual who performed the work had the required qualifications.

Current processes to ensure compliance, safety and airworthiness are error prone and expose OEMs to undue risk.

- Service records, maintenance manuals or drawings might not be up to date. Efforts to document compliance might result in inaccurate reports.
- Information is not available at the point of need. Mechanics constantly refer to paper documents or technical manuals to validate that what they are doing is proper. This introduces delays and inefficiencies into maintenance execution.
- The lack of a common repair environment across all depots makes it difficult to manage maintenance standards, capture lessons learned or apply best practices for continuous improvement.

Create a seamless digital record that spans the system's life

A digital knowledge-based environment makes it possible to capture a current, comprehensive digital record spanning the sustainment phase of a system/platform's life. This life-long BOM confirms that every action taken, every decision made and every process followed was proper and conformed to applicable rules and regulations. Service bulletins, airworthiness directives and other changes to the configuration can be received electronically and uploaded automatically. Since this information is maintained in electronic form, quality compliance officers can cross-check a part or process with the master file to validate compliance with the latest directives from the design authority or to take proactive steps to address non-conforming parts or processes.

By establishing a common digital environment for MRO based on PLM, service organizations create a seamless digital thread from the OEM to the service provider. This eliminates the need to constantly check technical manuals to make sure that procedures, work cards and work instructions are accurate. It also provides highly automated, disciplined MRO processes that can be applied consistently across the organization and its facilities. As a result, compliance with customer and regulatory requirements can be assured. By linking engineering, manufacturing, logistics and sustainment, this environment makes it possible to continuously improve the quality of next-generation products through continuous feedback on maintenance actions and operational performance.

Can you readily correlate service experience with failure rates to accelerate upgrades and enhancements?

Military engines and aircraft are frequently re-engineered to meet enhanced operational requirements, improve performance or stay current with changing communications and safety standards. When changes occur, all of the data generated over the platform's service life needs to be shared with design engineering so that a new design can be created. Most OEMs find it difficult to manage the upgrade and enhancement process, resulting in significant knowledge gaps that cause unnecessary delays or budget overruns.

Efforts to accelerate or simplify this process face significant challenges.

- The link between design engineering and MRO is often broken or weak at best. Before any redesign effort can begin, design engineers must receive an updated history of the system/platform that reflects events which have occurred since they handed off the as-designed BOM.
- It is difficult to assess and communicate the root cause of underperformance in a way that clearly defines what re-engineering work is necessary. Knowledge of the system/platform, LRU, or part and its maintenance history often resides on paper or in the heads of individuals who have come in contact with it over its 30-year service life.
- Without adequate information, operating engineers find it hard to accurately gauge the time, resource and budget required to re-engineer a faulty part or LRU.

Connect MRO with design in a continuous feedback loop

A digital solution that provides a single repository for a comprehensive BOM along with its associated operating experience and failure rates can accelerate and simplify upgrades and enhancements. Within this repository, the "DNA" of every system, subsystem or functional area of a system/platform can be tracked. This establishes a clear baseline, along with a detailed history of what has happened to the system, when it happened and how it has performed operationally.

All of the information traditionally recorded in the log book is maintained in electronic form and can be managed in an automated fashion. For example, the results of failure modes and effects can be embedded into the master repository and associated with the BOM. As a result, operating engineers can monitor the service experience and failure rates of any given system, subsystem, or part. Since the product's operating experience and history are all related to the BOM, weak areas and root downtime causes become readily apparent. This knowledge can be used to continually assess the integrity of a design against expectations and make better, more timely decisions on whether to alter inventory policy or to redesign faulty systems. Equipped with an accurate baseline, operations engineers can establish the scope and budget for any re-engineering effort. Design engineers can access the information they need to evaluate design changes in the context of the system's service history.

Conclusion

As aerospace and defense OEMs take on greater responsibility in managing the service life of military systems or platforms, they are being held to measurable outcomes in performance-based logistics contracts. In order to reduce cycle times and return critical platforms to an operational state within contractual constraints, customer service and product support executives are transforming their operations and implementing enterprise-wide digital solutions to capture and manage MRO knowledge, processes and results.

According to Hal Chrisman, principal, Aerostrategy LLC, this emphasis on performance-based contracts is compelling the MRO business to move to a more proactive service model that emphasizes lower total cost of ownership and maximum availability at a reasonable cost.[4]

By implementing an enterprise-wide digital PLM environment for MRO in cost-effective stages, customer service and product support executives can address the most important challenges associated with achieving these goals. In particular, PLM makes it possible to:

- Gain visibility into service history and requirements for all systems/platforms and across all facilities under their control. All versions of the BOM can be managed within the context of the system/platform configuration – including the BOM's as-built, as-planned, as-maintained and as-operated states.
- Optimize maintenance planning and inventory. Lean MRO practices can be captured and shared across the service value chain.
- Link the MRO value chain with design engineering, manufacturing and sustainment in a collaborative digital environment. Online real-time access to the lifecycle history of a system, LRU, or part makes it possible to rapidly identify performance issues and provide the information needed to streamline re-engineering efforts.
- Increase work force productivity dramatically. More work can be performed more efficiently, with higher accuracy and predictability. By capturing service data and experience during the course of their work, service organizations also create a vast MRO knowledge base that can benefit future work forces.

Knowledge-centric solutions based on PLM provide an effective way to achieve these business goals. These solutions establish a single source of comprehensive, accurate and synchronized knowledge across the MRO value chain and at all stages of the system/platform's service life. By capturing, synchronizing and maintaining a system's configuration and related operational information in digital form, PLM provides the visibility and the tools needed to proactively manage the continuous flow of changes and the daily maintenance activity performed across all facilities, from the point of title transfer to retirement.

PLM capabilities that support MRO include:

- Integrated data management capability, across the enterprise and across the product lifecycle
- Comprehensive in-service management capabilities, including asset tracking, documentation and compliance
- Rich visual applications for maintenance planning and execution that increase productivity of direct forces
- Service reporting and analytics tools that document performance metrics

[4] Op. cit. *Ready for Takeoff*.

In order to manage MRO operations at an enterprise level, military OEMs need to embrace PLM technology tailored and scalable to their business needs. PLM addresses the barriers to improving fleet availability and reducing costs, resulting in:

- MRO cycle time and cost reductions
- Improved system/platform availability
- Increased productivity of direct and indirect forces
- Improved use of working capital
- Assured compliance, safety and airworthiness
- Demonstrated achievement of service and performance-based contracts

To learn how military OEMs are creating an enterprise-wide, digital environment and transforming their MRO processes, visit: http://www.plm.automation.siemens.com/admro

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