IBM Software
Tivoli

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Effective configuration management for complex assets

IBM configuration management solutions

Contents

Executive summary

Configuration management presents a unique challenge to companies who operate or overhaul assets such as aircraft, aero-engines, locomotives and other complex, component-based assets. It is critical for these complex and dynamic assets to be managed throughout the entire asset and service life cycle. Organizations that manage these complex assets can range from airlines to railways, original equipment manufacturers (OEM) to aftermarket service providers, from defense forces to civilian agencies. Configuration management is an essential part of monitoring and managing these organizations' efforts to comply with regulations, meet safety requirements, minimize maintenance costs and optimize asset reliability and availability.

Conventional systems for managing Maintenance, Repair and Overhaul (MRO) data have often proved inefficient because they rely on a cumulative transactions approach that represents only the latest configuration. Prior configurations cannot easily be extrapolated, and retrospective corrections are complicated and error-prone.

What is required is a complex asset life-cycle management solution that can actively manage and calculate MRO-related data in real time, from any point in time. This capability, called component life accounting, can save time and money and help reduce operational and compliance risk, but will also better support data conflict management, data cleansing and forecasting activities while providing a more straightforward interface to external systems.

Introduction

Modern assets operating in the aerospace, defense and rail sectors represent an extremely complex equipment class. These strategic assets have thousands of safety-critical parts that are exceptionally challenging to manage and maintain, even in the absence of regulatory and safety mandates.

For commercial airlines, the military, aircraft and engine original equipment manufacturers (OEMs), rail operators and other organizations that maintain complex assets, the ability to correctly track the current and historical changes to configurations is vital to success. Traditional approaches have for the most part failed to provide this capability because they cannot easily support changes and corrections. The result is increased compliance risk and lost productivity due to time-consuming, error-prone manual processes. What maintenance decision makers need is a fully automated solution for asset life-cycle management that provides accurate, real-time configuration data on demand—not just for current configurations but for any prior configuration or point in time.

This paper outlines solution requirements and technology best practices for the automation of complex asset life-cycle management for organizations that maintain complex assets and their associated major assemblies, as well as for service providers offering Service Lifecycle Management (SLM). It discusses fundamental capabilities for the complex life-cycle management of asset configurations, including key capabilities for real-time historical component life accounting.

Today's compliance activities require access to real-time asset configuration data.

Service Lifecycle Management

A growing trend in aviation, Aerospace & Defense and railways is for the asset owners and operators to outsource maintenance to service providers. Many Original Equipment Manufacturers (OEM) offer aftermarket care programs for their equipment, as well as for competitors' products. Airlines often operate separate businesses for airframe, engine or component overhaul, and there are many third-party service providers who refurbish and rebuild aircraft or railway assets. This process is called Service Lifecycle Management (SLM).

Companies engaged in SLM have recognized that there is significant revenue value to be obtained by providing a full range of services to the aftermarket. In providing this aftermarket service to the asset owner or operator, the SLM provider takes on significant risk in guaranteeing defined levels of performance, service and reliability. OEMs, in particular, are well positioned to provide aftermarket services based on their inherent knowledge of their product and the capabilities of their workforce. However, the infrastructure required to support aftermarket services differs significantly from those systems and processes required within a pure manufacturing environment. Conversely, airlines and aftermarket service providers are typically well suited for managing overhaul and maintenance processes, but have less product intimacy than an OEM. Having knowledge of the asset's design and maintenance processes are strategic to success.

For all those engaged in SLM, a key element of the aftermarket services infrastructure is the ability to manage and validate the in-service "as-maintained" asset configurations, record asset life usage and in service events, including unscheduled failures and scheduled maintenance, and manage the applicability of design changes across the range of asset types. These requirements present a number of challenges that require specific functionality of the supporting systems.

Complex asset life-cycle management

The commercial, corporate, and defense organizations managing their own assets, as well as SLM companies, all strive to decrease overall maintenance costs and maximize the operational readiness of assets, while ensuring the safety of passengers, crew and cargo.

One of the biggest stumbling blocks to achieving these goals is a dependence on outdated IT systems that cannot efficiently provide the real-time information that today's compliance monitoring and management require. A limited ability to manage and track MRO-related data, and to accurately represent the configurations of assets and components over time, means that assets are often overmaintained and asset life cycles shortened to ensure that safety is not compromised.

As a foundation for automating these and other asset life-cycle management functions in complex and heavily regulated operational environments, four capabilities are critical.

- Configuration management
- Component life accounting
- Operational status management
- Event management

These software building blocks form the core of an overall asset management solution, and they define the level of usability, flexibility and functionality it can offer.

Configuration management

Configuration management combines historical MRO information with an asset's original manufactured configuration to provide a comprehensive view of an asset's history. Configuration management can also help to confirm that actual aircraft or component physical assemblies comply with allowable configuration rules, e.g. Service Bulletin effectiveness and embodiment—and alert operators when they do not. The configuration management system may also represent functional builds—for example, an "electronic systems only" view of the equipment.

A robust configuration management solution is the single most important component of the asset life-cycle management system. Effective configuration management enables organizations to plan maintenance more accurately and to help ensure asset availability, confirm regulatory compliance and maximize the value of an asset throughout its life cycle. The more complex and dynamic a fleet is, the more important effective configuration management becomes. For example, both as-designed and as-built asset configurations are normally highly volatile data structures. It is therefore important that configuration management support the integration of technical records and their impact on what is (and what is not) a valid physical build for an individual asset and its modification state. Likewise, configuration management should support the concept of assets being in multiple valid configurations at the same time.

Component life accounting

A successful aircraft life-cycle management strategy relies directly on an efficient underlying maintenance plan. In turn, the maintenance plan relies on the accurate accounting (not simply the tracking) of component life.

A component life accounting system must be able to derive physical build and component life data in real time from transactional logs, automate conflict detection and resolution, support unlimited backdated changes to install/remove and usage records, and provide an accurate view of historical, at-the-time, as-built and component life data.

The ability to manage configurations efficiently throughout each asset's life cycle enables a wide range of benefits.

Additional capabilities made possible by this approach should include improved maintenance forecasting, high-tolerance data conversion, distributed data management, store-and-forward capabilities, and more robust and flexible interfaces to external systems such as enterprise resource planning (ERP) systems or interactive technical manuals.

Operational status management

An asset operational status management system works by comparing an actual aircraft build to its intended configuration (or configurations) and then evaluating the current status of the asset's maintenance plan to determine an overall operational status.

The output of this complex evaluation process can be used to drive a status board or other reporting alert mechanism, providing an accurate, up-to-date view of overall fleet operational status. The more effectively organizations can manage fleet operational status, the better positioned they are to successfully manage and monitor their regulatory compliance efforts to optimize their maintenance program, likely resulting in improved asset performance and reduced costs.

Event management

An essential element of managing in service assets is to be able to record and analyze all events that occur on the asset. Due to operational imperatives this data may be received out of chronological sequence, the system must e able to make order from the apparent chaos that this out of sequence data may cause.

An Event is defined as an incident or occurrence, either planned or unplanned, that led to some activity being carried out. By capturing this event data in a structured manner it is possible to apply analytical techniques to assist in the prediction and forecasting of impending, preventable failures. For example, this capability is fundamental to an SLM Provider overhauling aircraft, where the ability to maximize on-wing time and predict asset life and associated services directly impacts the profitability of the business.

To properly support complex asset life-cycle management it is imperative for organizations to utilize a configuration management solution designed to capture the key data associated with in service events, such as:

- Symptoms – An event will always be initiated by a symptom, for example "High Oil Pressure" or "Cockpit Warning Indication."
- Reactions – The reaction to a symptom, for example "Engine shut down."
- Actions – The action(s) that is triggered by the reporting of the event, it can be assumed that if the Event had not occurred then there would be no action. An action may be a component replacement, an inspection process etc.
- Findings – A discovery and/or analysis of a problem.

A range of attributes associated with each element of an Event is captured in the configuration management solution and made available for analysis by specialized applications.

Benefits of effective asset life-cycle management

An organization's ability to manage asset and component configurations efficiently throughout each asset's life cycle enables a wide range of benefits. These include:

- Improved management and monitoring of regulatory compliance efforts, including improved readiness for both external and internal audits and reviews of maintenance policies, configuration change histories and maintenance records.
- Support for an optimized maintenance program that allows an organization to more accurately assess, manage and monitor components critical to aircraft safety and helping to extend component life and reduce the tendency to overmaintain components.
- Reduced record management costs and complexity compared to paper-based or inefficient, semiautomated systems.
- Improved supply chain sourcing, due to an improved ability to verify and manage alternate or replacement parts.
- Reduced inventory, through an improved ability to predict the need for replacement parts, combined with a better ability to identify which parts are obsolete for the current fleet.

A rules-based approach to asset configuration management ensures that changes propagate automatically to all relevant configurations.

Key solution differentiators

For most organizations, complex asset life-cycle management activities are only partly automated today. Traditional software applications fall short of providing a complete solution for two major reasons: they rely on templates to represent asset configurations, and they track asset life cycles using a cumulative transaction approach. More advanced solutions solve these problems in ways that greatly simplify compliance and reduce or eliminate manual procedures in response to human error, system down conditions, data integrity problems and so forth.

Template-based versus rules-based configuration management

The most powerful and flexible configuration management systems are rules-based rather than template-based. Traditional configuration management systems rely on configuration templates to represent as-designed builds for equipment structures. This means that an actual equipment structure is derived from a copy of a template. There are many problems with this approach. For example, actual equipment builds typically do not automatically inherit changes made to the templates they reference, necessitating manual intervention. The number of templates in use can easily proliferate unmanageably. Further, most template-based approaches are either overly simplistic (offering only one-dimensional applicability rules) or overly complex. Modification states often cannot be represented at all, leading to unreliable compliance results.

A rules-based approach, on the other hand, works by stipulating specific validations and actions against as-designed builds in specific contexts. A rules-based system permits the as-designed builds to be shared between all configurations within a model. The differences between configurations are maintained via rules only. This ensures that changes propagate automatically to all relevant configurations and as-built equipment assemblies. For example, a part number change would lead to the invocation of part supersedence/replacement rules, so that the impact on configurations can be handled automatically.

As these examples illustrate, rules-based configuration management systems are inherently more automated, more intuitive to use and much more effective at modeling the real world than template-based systems. A rules-based approach to aircraft life-cycle management is outlined in MIL-STD-1388-2B and other derivative standards.

Cumulative transactions versus component life accounting

One of the key capabilities that an effective asset life-cycle management solution must deliver is an accurate accounting of aircraft and component life histories, including the ability to efficiently resolve data conflicts and handle corrections. Traditional systems take "snapshots" of asset configurations at fixed points in time. If it becomes necessary to specify the configuration at a time in between the snapshots, such as to meet compliance directives, manual intervention and extrapolation are required. It may not be possible to know the past configuration precisely. The situation is analogous to old-style batch accounting systems, which provided end-of-day totals using accumulated balances but could not calculate an accurate balance at midday.

To ensure accuracy in support of more effective monitoring and management of compliance efforts and safety and maintenance optimization, organizations require a system that can pinpoint the precise configuration of an asset at any point in time and accurately reflect all maintenance activities. In short, they need a way to account for component life cycles in a manner similar to modern financial records applications, which commonly provide point-in-time balances through real-time calculation. This is the approach more advanced systems take.

The cumulative transactions approach

Figure 1 illustrates the typical transactional approach to component life tracking. A conventional MRO data system holds a hierarchy of status-tracked parts representing an as-built assembly. It updates this structure using install and remove transactions.

Associated with each component are meters that track life units. New usage transactions are applied to the top of the structure (i.e. the airframe, locomotive or passenger car) and trickled down the structure to affect all appropriate meters. These meters accumulate running totals for their respective usage type (i.e. flight hours, kilometers traveled).

The shortcomings of this approach quickly become obvious when transactional changes to the hierarchy become necessary in response to human error, a system crash, asynchronous data

distribution, data integrity problems and so on. For this approach to work, all install/remove and usage transactions must generally be applied in the correct order, mirroring the order in which the corresponding real-life events actually happened.

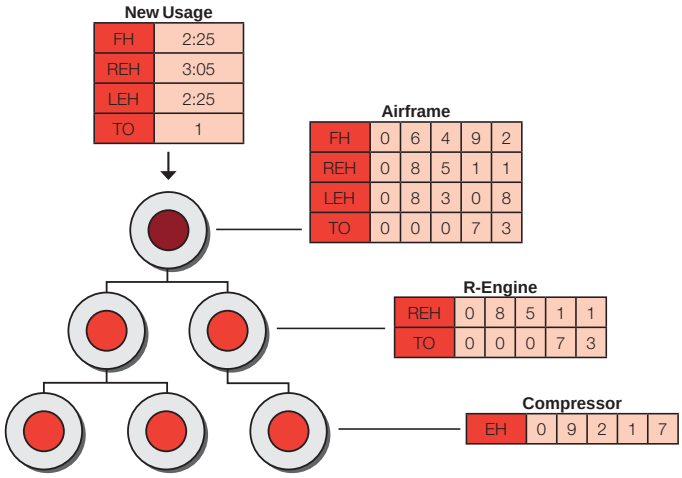

Figure 1: Conventional component life tracking, using cumulative transactions

Since only the latest as-built assembly and component life values are represented, any transactional change (resequencing, backdating or correcting any transactions) can be extremely complex and error-prone, and may require a very large number of database updates. To apply such a transactional change, it is typically necessary to work backwards from the current asset representation to reconstruct the asset as it was at the time, then apply the change, and then work forwards again, updating all effected assets and their components. The further back in time the change needs to be made, the more assets may be affected by the change, and the more complex the resulting database updates.

The component life accounting approach

Like a modern accounting or ERP system, an advanced MRO data system can dynamically manage transactions, derive asset configurations and provide asset history and audit trails—all in real time. A real-time approach to component life accounting calculates an asset's as-built structure and component life values from all applicable install/remove and usage transactions (including cycle formulas).

The capabilities of a real-time approach can include:

- The real-time application of backdated changes to install/remove and usage records.
- On-demand historical views of an asset, including its status, life at-the-time, and maintenance plan at-the-time.
- Extrapolation of future-time views to support advanced maintenance forecasting, operating cost projections, etc.
- Improved ability to manage data conflicts that arise from store-and-forward data distribution until they are resolved.
- Improved integration with external systems via real-time, transaction-managed interfaces.

IBM Maximo Asset Configuration Manager enables the real-time calculation of both asset builds and component life.

About IBM Maximo Asset Configuration Manager

Part of the IBM Tivoli® software portfolio, IBM Maximo® Asset Configuration Manager automates complex asset life-cycle management by more efficiently managing the current and historical configurations of complex assets and component assets. By enabling the real-time calculation of both asset builds and component life, Maximo Asset Configuration Manager helps organizations maintain assets more efficiently, extend asset life, improve reliability and availability and more effectively monitor and manage their efforts to meet the regulatory and safety requirements of the aviation, A&D and railway industries.

Unlike other asset life-cycle management solutions, Maximo Asset Configuration Manager provides active tracking of asset configurations. It generates current and point-in-time configurations dynamically upon request. This critical capability enables organizations to maintain aircraft MRO data with far less manual effort, and to meet requests for safety and compliance data more efficiently and with greater confidence.

Built-in features of Maximo Asset Configuration Manager include:

- Historical views of transactional changes and asset build and component life.
- Definition of as-designed allowable asset builds, including the ability to track design changes and Logistic Support Analysis Record (LSAR) data.
- Tracking of as-built asset configurations, including the ability to dynamically account for asset and component builds, life history, and life at the time.
- Automated, real-time interpretation of asset status to support maintenance forecasting and the development of optimized maintenance plans, including the ability to track maintenance events against serialized parts.
- The ability to accurately perform system and component analysis and reporting to support improved reliability and lower maintenance costs.
- Support for high-conflict-tolerant data conversion, management of distributed data and store-and-forward capabilities.
- Integration with a wide range of external systems.

Figure 2 illustrates the key software modules of Maximo Asset Configuration Manager. These include component life accounting, Configuration Rules Management for build configuration management, and the Build Data Interpreter (BDI) for operational status management.

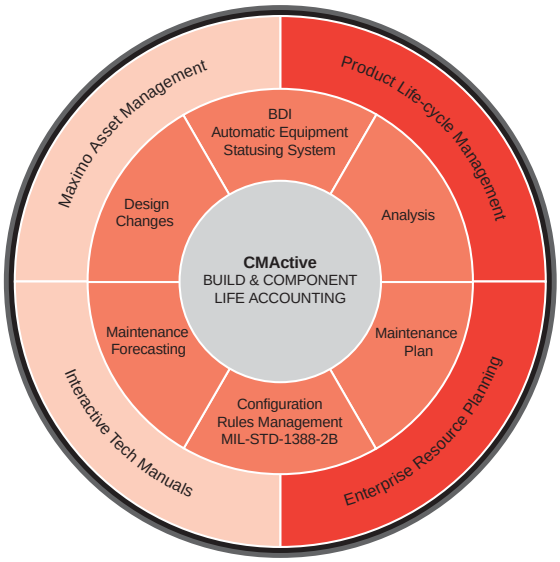

Figure 2: Components of IBM Maximo Asset Configuration Manager

Maximo Asset Configuration Manager integrates seamlessly with an organization's other asset management (production, facilities, IT, etc.) and work management functions through IBM Maximo Asset Management. For example, when the build and component life accounting component of the system calculates that a component must be replaced, a work order is automatically issued in Maximo Asset Management.

Maximo Asset Configuration Manager also integrates with interactive technical manuals, external ERP solutions and Product Lifecycle Management (PLM) and Service Lifecycle Management (SLM) systems to connect the design, current and historical asset configuration information.

The advanced Maximo architecture

Maximo Asset Configuration Manager and Maximo Asset Management comprise an adaptable asset management solution based on an industry-standard, service-oriented, Internet-ready architecture. This technology can provide an unsurpassed level of flexibility to meet dynamic business requirements, integrate with key systems like ERP and document management, and consolidate multiple legacy applications.

A successful asset life-cycle management solution provides automated configuration management, component life accounting and operational status management.

Conclusion

Traditional approaches to managing MRO data have generally been unsuccessful at automating configuration management, component life accounting and operational status management for complex assets. This has resulted in increased compliance risk, lost productivity due to frequent manual interventions, and an inability to optimize asset maintenance and maximize asset life.

To streamline operations and enhance efforts to reduce compliance and safety risks, organizations benefit from a fully automated solution that provides accurate, real-time configuration data on demand. This entails an advanced approach that tracks MRO transactions dynamically, like a modern financial application, while maintaining asset configurations using a rules-based rather than a template-based method.

Built on a standards-based, service-oriented architecture, Maximo Asset Configuration Manager offers a complete asset and service life-cycle management solution that dynamically tracks asset life-cycle activities and automatically generates current and point-in-time configurations—empowering executives to optimize maintenance activities, improve compliance processes and reduce operating costs.

For more information

To learn more about configuration management solutions from IBM, including IBM Maximo Asset Configuration Manager and IBM Maximo Asset Management, please contact your IBM representative or IBM Business Partner, or visit **ibm.com**/tivoli/maximo.

About Tivoli software from IBM

Tivoli software provides a comprehensive set of offerings and capabilities in support of IBM Service Management, a scalable, modular approach used to deliver more efficient and effective services to your business. Meeting the needs of any size business, Tivoli software enables you to deliver service excellence in support of your business objectives through integration and automation of processes, workflows and tasks. The security-rich, open standards-based Tivoli service management platform is complemented by proactive operational management solutions that provide end-to-end visibility and control. It is also backed by world-class IBM Services, IBM Support and an active ecosystem of IBM Business Partners. Tivoli customers and partners can also leverage each other's best practices by participating in independently run IBM Tivoli User Groups around the world—visit www.tivoli-ug.org

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