

A BUSINESS CASE FOR USING INTEGRATED DOCUMENT MANAGEMENT IN AN MRO ENVIRONMENT

EXECUTIVE SUMMARY

Maintenance, Repair and Overhaul (MRO) operations require a large amount of information that must be current, accurate, integrated, easy to maintain and publish in order to run effectively within maintenance, engineering and operations business realms. The costs of using an integrated content management based MRO solution for most documentation and records are easily recouped by savings in productivity, head count and software maintenance. Avoiding costly non compliance issues is potentially larger in terms of justifying the costs of a good integrated MRO solution.

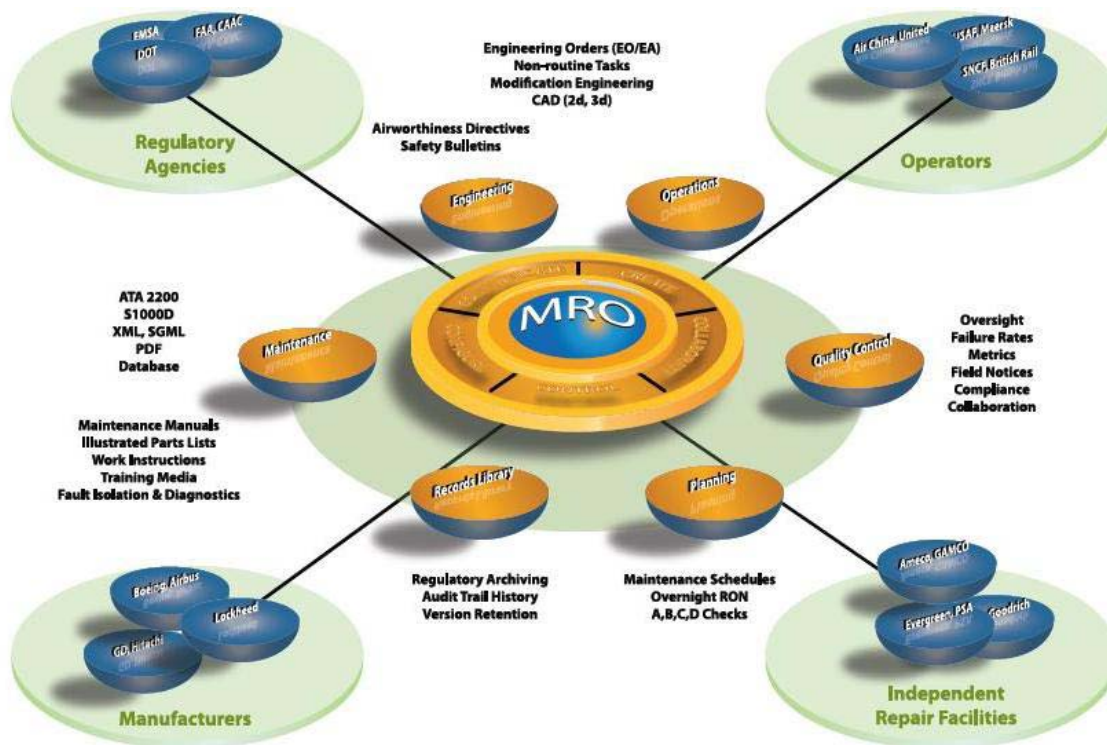
Most MRO solutions that airlines and MRO suppliers use are considered 'pure play' MRO tools in that they address the core needs of the MRO process in planning, inventory management and tracking human resources. Examples include Trax, Maintenix and AMOS. Handling documents in a consistent, intelligent manner is often an afterthought. This niche of providing smooth interactions with heterogeneous documents is often filled by 3rd party vendors as part of the overall MRO solution. Examples include TerraMRO and Open Connect. The focus of this document is on the needs of an integrated document management solution within the overall MRO solution.

Building an effective ROI story to justify using an integrated MRO solution runs into the same issues any software system encounters. The hard costs of avoiding print and distribution of manuals is generally easy to calculate and defend. Softer costs like increased productivity or reduced head count are more difficult to assign values to and defend. For example, if the tech pubs department is 25% more efficient in processing revision services from OEM and regulators, it generally is not the case that a quarter of the staff can be let go to help fund the system. In reality, these personnel will likely get reassigned to more productive tasks and after that process will any overstaffing conditions be evident. Given that, the sheer volume of the document and change management work being performed and the efficiencies using a well designed integrated document management system should be easy to demonstrate and justify. This document provides some starting points to help an MRO organization with that assessment.

Beyond a convincing ROI story, any maintenance organization must assess the risks inherent in the use of their IT solutions to manage the document management and change management aspects of their maintenance process. The initial and recurrent costs of maintaining compliance using effective and well integrated tools can easily be overshadowed by the risks of using tools that don't provide effective checks and balances. Since the ultimate goal of any maintenance organization is to maintain the safety of flight, a well designed fully integrated document management and change management MRO solution is a cost effective and risk-averse approach to carrying out that mission.

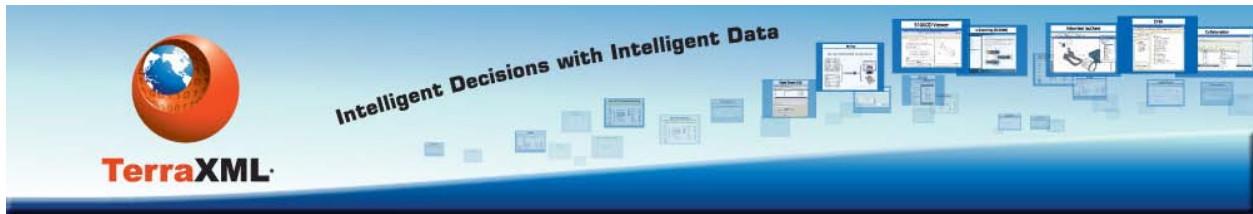
CURRENT MRO ENVIRONMENT LANDSCAPE

Today's business environment for MRO operations typically includes multiple systems tied together in an ad-hoc manner. The extent of the business is demonstrated in this graphic:



With so many related processes interacting just for the documents governing the maintenance process, it's important to ensure access to information across the business and beyond to external partners and regulators. There currently is no single solution that integrates every part of the large MRO business process. Each MRO and operator typically lashes together a solution from software products that serve MRO niches and then builds homegrown solutions for missing pieces or builds manual processes. Even choosing a 'pure play' MRO solution such as Maintenix or Trax often doesn't address the full needs of managing documents, displaying them intuitively and providing a good change process for new and modified content.

Given this landscape, there are still strategies to organize information into smaller silos. Doing so will promote reuse of common data, avoid inconsistencies, reduce manpower spent on repetitive tasks, etc. An integrated document management and change management MRO system may not cover all functional areas and will communicate with some other operational or planning systems to provide the full feature set needed to run the MRO or maintenance operation efficiently.



COMMON PROBLEMS

Many problems exist in any MRO or operator environment as information systems evolved from paper or manual processes into electronic systems. This transition continues today and will continue as MRO systems become more sophisticated and integrated with other core MRO tools such as planning and inventory systems.

TOO MANY MOVING PARTS

Information is often in too many silos, often duplicated and inconsistent. A partial list of the usually independent systems holding key MRO information includes:

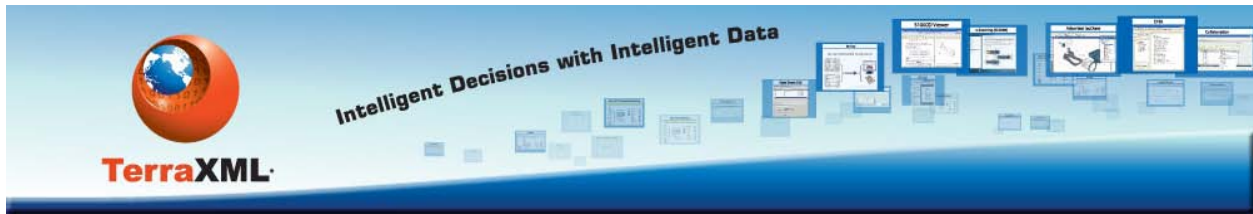
- **Maintenance Manual system**, online in various formats, often PDF but sometimes HTML/XML
- **Job card system**, often loosely tied to AMM tasks that require much manual review to keep cards current with AMM revisions
- **Engineering system**, which is often an informal arrangement for reviewing AD/SB and then writing EO's in Word or other formats
- **Maintenance Program system**, often little more than spreadsheets or Access databases and an ad-hoc review and approval process involving reliability and other departments
- **Planning system**, a complex system that uses historical data, current aircraft utilization data and predictive formulas to determine what maintenance need to be done when. Most MRO organizations adopt MRO pure play tools such as Maintenix or Trax to support this particular need.
- **Aircraft Records system**, often relying on scanned images of signed documents.
- **Configuration management system**, often duplicated and built into each subsystem as needed to provide easy access to things like fleets, aircraft tail numbers, vendors, part numbers etc.

Having so many systems responsible for overlapping functional areas will lead to confusion and duplication of data. Feeds between systems become expensive as custom interfaces will be required, or managed by inefficient manual processes. The business need to augment many MRO pure play tools with specialized document management solutions adds to the burden for providing smooth user interaction and behind the scenes interfaces.

The goal of a unified document management and change management MRO solution is to minimize the complexities of different systems and provide tighter data integration between unique business processes like engineering, planning, production maintenance, technical publications and records for documents used in the maintenance and engineering process. This will help avoid the costs of duplicate data that must be validated and corrected on a continuous basis.

TRAINING OBSTACLES

MRO organizations have limited resources for training and recurrent training for a large and ever changing staff. Training is focused on keeping technicians current on skills needed to perform the revenue generating maintenance of the MRO business. If extensive training is required to use MRO document management and change management computer systems, several problems are readily apparent:



- Complicated systems that require training often lead to lower usage due to complexity and time
- Training resources to train a large number of mechanic staff need to be allocated and reduces time doing productive revenue generating maintenance
- Time using the MRO system on a daily basis may be longer than desirable, sometimes up to an hour per shift per mechanic
- Recurrent training is probably necessary to ensure adequate skills are maintained
- If there are high turnover rates or job changes within the organization, the training burden and cost will increase
- Interactions with the document management aspects of the MRO process and pure play MRO tools that manage planning, inventory and resource management are often specific for each customer based on the product choices made.

Obviously the goal is to make systems easy to use with minimal training. Current MRO solutions that comprise a variety of tools using various user interfaces, protocols, nomenclature and designs are an obstacle to an efficient operation. A document management and change management solution that uses intuitive web browser display and search user interfaces will increase usage and decrease errors. It still needs to interact with back end MRO functions that may or may not be part of the document management and change management solution.

PROCESS VERIFICATION ISSUES

An MRO or operator has a need to show its internal QA and regulatory authorities that it follows a predefined plan with actual work done properly, signed off and done at the correct intervals. When information is in different locations or systems this often becomes difficult and time consuming to do. In addition it leads to more stringent oversight and costs if the regulator can't easily see this on an ad-hoc basis.

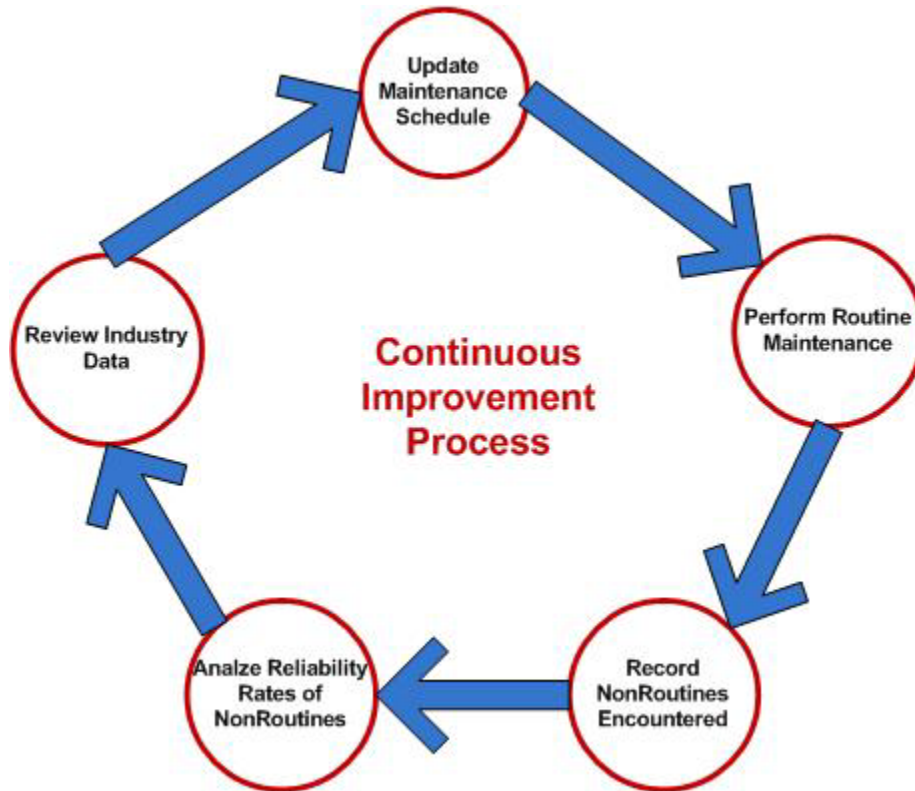
The goal of an integrated document management and change management MRO solution would be to easily show how maintenance tasks are planned, packaged, assigned, worked, signed off and recorded and that accomplish the overall goals of the maintenance schedule. Links between the parts should exist as much as possible in an interactive manner.

The use of a document management and change management MRO system in conjunction with other MRO software may require some specialized customizations to provide the full 'spec path' to show the actual application of the goals defined in the maintenance schedule approved by the operator and its regulators.

DIFFICULTY REVIEWING OPERATIONAL DATA TO SUPPORT CONTINUOUS IMPROVEMENT

Any maintenance organization, either MRO or operator, strives to improve performance without impacting safety. There are many advantages to performing maintenance at the correct time and level before failure is predicted but not so early that the useful life is wasted and costs incurred unnecessarily. Finding the right level is often difficult in current environments but when reached by simplifying the data creation and analysis can have dramatic savings in actual maintenance costs and reduced out of service times.

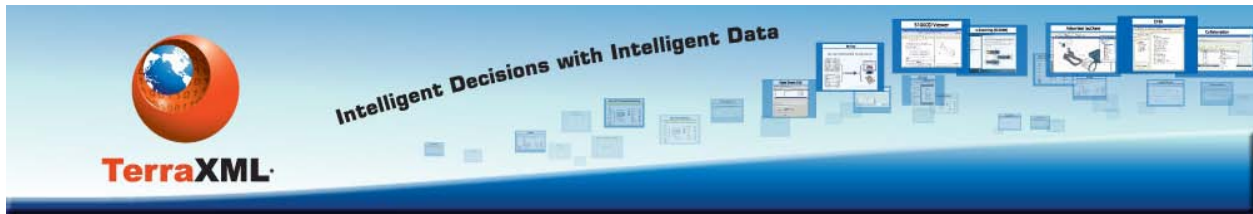
The basic structure for a continuous improvement program is a cycle that starts with a maintenance plan and flows to the job cards that accomplish the goals of the plan, the packaging of these cards into routine maintenance checks, the actual planning and accomplishment of the work, the recording of job card signoffs and non-routines generated along the way, analysis of the non-routines and adjustment of the maintenance plan based on the reliability data collected. This process is demonstrated in this graphic:



The goal of a good MRO solution would be to facilitate the continuous improvement process by keeping the data in common data stores that can be passed or accessed from different modules that are accomplishing different design goals. For example, non-routines are often generated on paper forms on the shop or hangar floor and are not easily combined into trends by the reliability analysts. The usage of an integrated document management and change management MRO solution in conjunction with other MRO tools will provide capabilities to improve process improvements. Links between the various MRO tools need to be customized to provide this functionality.

AUTHORING ISSUES

Engineers and tech writers often have needs to create documents based on changing maintenance conditions. With multiple systems or ad-hoc procedures it is often difficult to create documents that are consistent and easily shared across the enterprise. MS Word templates are often used to provide a basic structure to document types but ultimately the information is often in free form and difficult to exchange or leverage in other areas of the



system. Authors often have to grapple with graphics using various tools that produce proprietary or renditions that are incompatible with other users in the business.

Many documents need to be created on the fly during normal operations. This includes authorizations by engineers to perform special maintenance that falls outside of routine job cards. It can also include non-routines generated by the mechanic on the production floor. The creation and usage of these documents is often not well integrated into the system and must be managed by hand.

A goal of an integrated MRO document management and change management solution is to provide good quality designs for documents that can be authored and shared across the enterprise. XML based documents are a good design choice for data exchange and reusability but it isn't absolutely mandatory. However, Engineers often need to create their documents on the fly on the floor away from their desktops so lightweight creation and editing within browsers is desirable.

CHANGE CONTROL ISSUES

Many things happen in a production environment that affects the maintenance process. All too often, the procedures to identify and resolve these issues are overly manual and complicated. This again relates to multiple subsystems that aren't well integrated. For example, an AD or SB that arrives may get placed into one repository. Then some notification to other groups such as Engineering must occur. While Engineering such as Planning and Inventory Control assess the impact, there often is no visibility of the current status. The simple question of who is doing what and when is often answered in multiple queries to multiple systems or individuals.

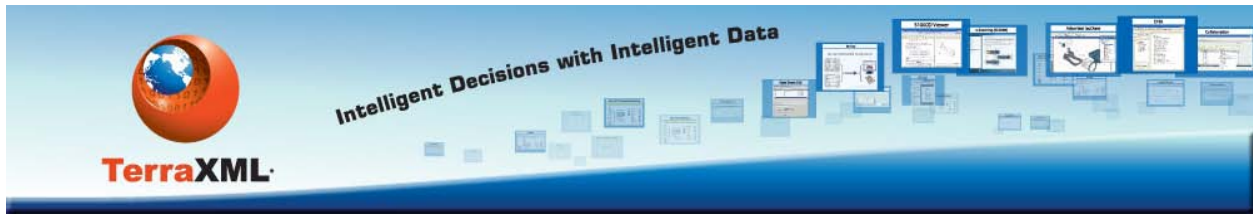
A unified MRO document management and change management solution will generally take advantage of a common change control process with constructs like inboxes, groups and role definitions, email notification, routing workflows, online reporting and escalation procedures when due dates are missed.

ADDITIONAL FINANCIAL AND OPERATIONAL RISKS

RISKS OF NON-COMPLIANCE

Aircraft operators and maintenance repair stations are governed by operational certificates issued by national regulatory bodies that issue guidelines on requirements for safe operations. Any violation of the published regulations can result in actions that can impact the MRO or operator. Fines can be severe as in the recent cases of maintenance documentation noncompliance MEL issues totaling \$7 million at American Airlines and a \$10 million fine at Southwest Airlines for missing repetitive AD related maintenance scheduled events. Even worse, operations can be shut down until noncompliance issues are satisfied. Fixing systemic problems in documentation, engineering change control and planning is not easily solved overnight.

In addition to severe fines, noncompliance can result in grounding of aircraft until the noncompliance issue is resolved to the satisfaction of the regulatory bodies. This can be difficult to do quickly and the loss of income from reduced operational capabilities can be hundreds of thousands of dollars per day. In the extreme, operating or repair certificates can be withdrawn on the MRO or operator which would remove any ability to generate revenue.



Lastly, noncompliance events will typically result in more scrutiny of the MRO or airline operator. This will add costs for providing staff to compile and research inquiries from the regulatory bodies.

DISTRIBUTION COSTS

Getting updates out to the field and hangar locations is a costly proposition. Typical costs that are incurred include:

- Printing costs of document, including paper, ink, printers and servicing
- Labor costs of printing, batching, preparing routing documents, boxing and shipping
- Postal costs whether it be internal COMAT, postage, Fedex
- Labor costs of receiving updates, unbundling, applying updates

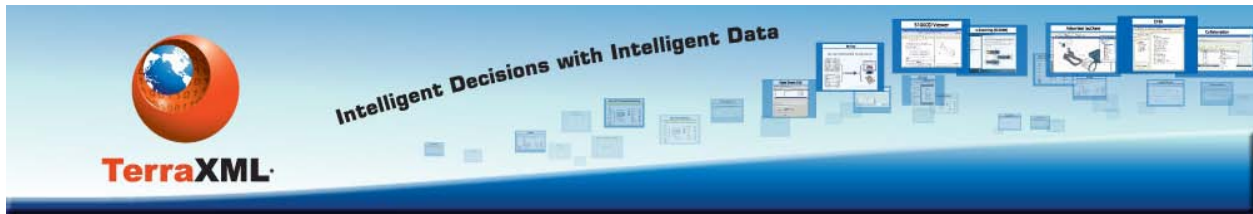
COSTS OF MANAGING CONTROLLED DOCUMENTS

Many documents used by mechanics and engineers are referred to as **controlled documents**, meaning that it is important that everyone must always be using the correct, approved version. Regulatory Auditors will randomly inspect documents in the field to assess whether they are accurately maintained and current. In traditional paper based systems, this often meant sending out updates with specific 'change page' instructions that must be followed to replace content accurately without having to replace the entire document set. CD based systems bypass the need for the change page process but still require an effective distribution system and feedback loop to ensure compliance has been accomplished.

Some organizations set up elaborate schemes to ensure that updates are applied accurately across the enterprise and to external suppliers and regulators. For example, broadcasts to the field often require the field to signal back to the tech pubs department that they have received and applied the updates. This creates a heavy manpower burden on both ends to ensure the documents are maintained correctly. When this encompasses AMM, IPC, troubleshooting manuals, GMM and others across multiple fleets and customers it can become full time jobs just keeping the documentation current.

The risk in having loose procedures for managing controlled documents is that a regulator can be unsatisfied with the level of compliance and levy penalties, fines or worse depending on the situation. With a loose procedure, the MRO or operator also bears a heavier burden to internally review the adherence to the policies. Often with a loose procedure, the MRO or operator may find problems and have to self disclose these issues to the regulator, which again can lead to sanctions.

The obvious solution to mitigating controlled document issues is to avoid distribution and ensure all users are accessing the current and correct version of content in a central place in the MRO system. The MRO or operator should add additional procedures to ensure printed copies are not saved for long term use will go a long way to avoiding issues with controlled documents.



SUMMARY OF PAIN POINTS IN EXISTING MRO SYSTEMS

The previous discussions have touched on many common document management and change management issues in current MRO environments. The following table summarizes some of the key pain points in maintenance and engineering data support:

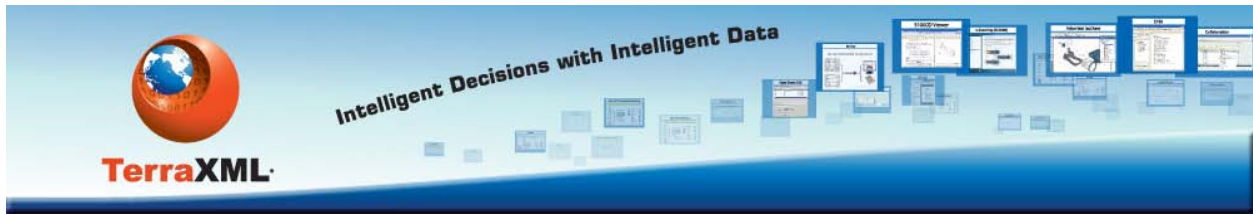
Key Pain Points
Inconsistent data in different locations.
Need to access different systems, each with unique own interfaces and behavior.
Difficult to follow references from one document to another.
Too much manual labor required to maintain current and accurate set of data.
Difficulty in handling and distributing temporary revisions to controlled documents.
Little or no alerts when changes in a document could affect others.
No consistent change process and little visibility about current change status.
Training issues with different systems and dispersed staff.
Difficulties in showing regulators that maintenance plans are being followed.
Disjointed data makes attempts at continuous improvement difficult.
Engineering documents authored and published in ad-hoc systems and not part of the regular change process that uniformly handles all external requests.
Major risk of fines for non-compliance due to uncoordinated activities like AD items that need to become repetitive tasks within the routine maintenance schedule.
MRO pure play solutions don't often handle document and change processes well and need augmentation by 3rd party tools.

REAPING BENEFITS FROM AN INTEGRATED MRO DOCUMENT MANAGEMENT AND CHANGE MANAGEMENT SOLUTION

So what specific benefits can be attained from a well integrated MRO document management and change management solution? And what specific Return on Investment (ROI) metrics exists to justify the cost of a system like this? This section will summarize the benefits and provide some metrics to assess the returns of using an integrated MRO solution.

CHARACTERISTICS OF AN INTEGRATED MRO DOCUMENT MANAGEMENT AND CHANGE MANAGEMENT SOLUTION

An integrated MRO document management and change management solution needs to be engineered from the ground up instead of lashed together with whatever is on hand or custom built by necessity in the past. A core repository technology should reside at the center of the MRO document management and change management system to control content, provide secured access to the content, provide library management and manage uniform change control procedures for routine and ad-hoc revisions.



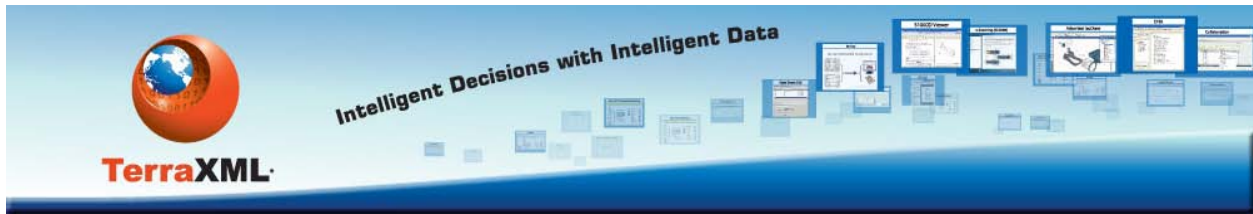
Some key design goals to build an effective MRO document management and change management solution include:

- Provide a **Single viewer** for all document types from all sources that uses standard web technology and thereby promotes usage and eliminates need for initial and recurrent training.
- Ensure users **only see approved versions** of content at all times, reducing chances of non-compliance.
- **Hide details** of back end content management constructs from end users so they only need to focus on getting or providing the information they need to do their daily tasks.
- Provide an **intuitive search** and navigation links in the viewer so that content is easily discovered and referenced across multiple data sources such as AMM, IPC, SB, EO and job cards.
- Provide a **simplified inbox** and workflow task participation so that changes are easily performed and status is visible across the business.
- Allow intuitive **authoring** of Engineering documents to authorize unscheduled repairs in EO's and smaller focused EA's, including the ability to do this in the field with minimal desktop authoring tools.
- **Record accomplishments** of maintenance activities to be stored in the content management system and/or returned to the Operator for storage in a records system.
- **Provide Integration Services** to popular installed M&E MRO pure play systems that support planning and inventory functions, such as those provided by tools like Maintenix, Trax, SAP, SCEPTRE, Maxi-Merlin.

BENEFITS OF AN INTEGRATED MRO DOCUMENT MANAGEMENT AND CHANGE MANAGEMENT SOLUTION

An integrated MRO document and change management library provide a common way to manage all information media – written text, graphics, video, scanned in, etc. This provides benefits such as allowing links between documents, sets the stage for document reuse, provides a standard way to search all documents, establishes common document control and provides a common interface to display all documents. It's kind of like comparing the usefulness of individual collections of books stored in people's houses to the usefulness of a library. The library takes in all the books, classifies them, controls who gets to see them, and keeps them updated so that all approved individuals have access to them. Having the book in your own home is convenient, but the selection is limited, the books get out of hand, and then everybody's buying the same books. Nobody knows who has what. An integrated document and change management system offers a way to get a handle on one of the most valuable assets of an MRO organization – information.

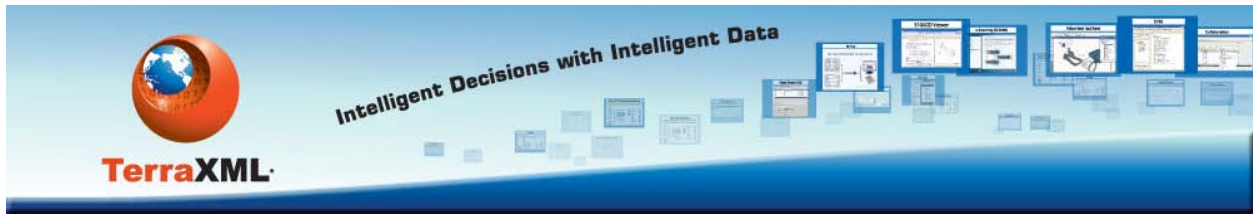
Not only is this information secure and accessible, but a document and change management solution offers ways to control its production, to link different pieces of information together, and to build new content from the content stored in the library.



An integrated library needs to work well with an overall MRO solution, possibly involving other MRO software tools. An integrated document and change management solution needs to offer API's that allow job card packages to be built, to retrieve specific content, or to extract useful data from information that might originate or be accessed from external systems.

This list summarizes some key benefits that can be quantified to some degree at any MRO or operator as part of an ROI analysis:

Key Benefits
Smaller overall costs than separate systems.
Easier support due to reduced complexity.
Lower maintenance costs due to reduced number of software components.
Reduced training due to simplified interfaces.
Consistent infrastructure model across subsystems ensures easier user access and usage.
Easier to show compliance of controlled documents since documents are maintained in the central server.
Unified change control process for all types of changes, including EO, job card, AD/SB/SL, manual revisions.
Greater visibility of what has changed and when.
Improved efficiency and accuracy, particularly with respect to high volume maintenance activities such as IPC lookups and job card assignment and signoffs.
Lower process administrative costs of maintaining smaller number of systems and reduced number of data locations.
Higher visibility on running engineering and maintenance change processes.
Reduced number of manual, paper-based steps.
Better service-level effectiveness due to reduced complexity of systems and integrations.
Quicker implementation of new content and changes based on them.
Shorter project cycles and costs for custom software improvements due to reduced integration and design complexities.
Overall reduction in the total cost of application development and maintenance due to a product based approach vs. a home grown custom solution.



SPECIFIC ROI METRIC WORKSHEETS

The following worksheets can help assess the actual cost savings for using an integrated MRO solution. Some may not apply, for example if manuals are already posted online.

Printing Costs – use these metrics if paper is actually produced for distribution. If CD/ROM is used, skip this cost.

Print Costs (PC) = Number of pages in the manual (NP)
 X cost per page (CPP*)
 X number of revisions per year (NR)
 X number of copies (NC)
 X number of fleet types and variants (NF)
 * - for cost per page include paper, ink, printer usage etc. Don't include soft costs like labor

Example:

AMM's for these fleets - 737Classic/737NG/757/767/747/A320
 (where NP = 1000, CPP = .02, NR = 4, NC=20, NF=6)

PC = 1000 x .02 x 4 x 20 x 6 = **\$9,600** per year for print costs only for AMM, not including temporary revisions (TR).

Your Values:

AMM PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
IPC PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
FIM PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
GMM PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
WDM PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
SRM PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
??? PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year
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??? PC =	_____ (NP) x	_____ (CPP) x	_____ (NR) x	_____ (NC) x	_____ (NF) =	_____ per year

Total Printing Costs of all Manuals _____ per year

Distribution Costs

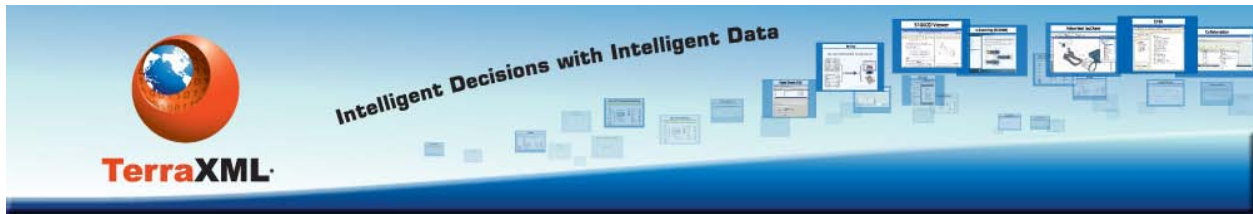
Distribution Costs (DC) = Shipping Charge per manual (SC) (prorated if combined/shipped with other manuals)
 X number of revisions per year (NR)
 X number of copies (NC)
 X number of fleet types and variants (NF)

Example

AMM's for these fleets - 737Classic/737NG/757/767/747/A320
 (where SC = \$10, NR = 4, NC=20, NF=6)

SC = 10 x 4 x 20 x 6 = **\$4,800** per year for distribution costs only for AMM.

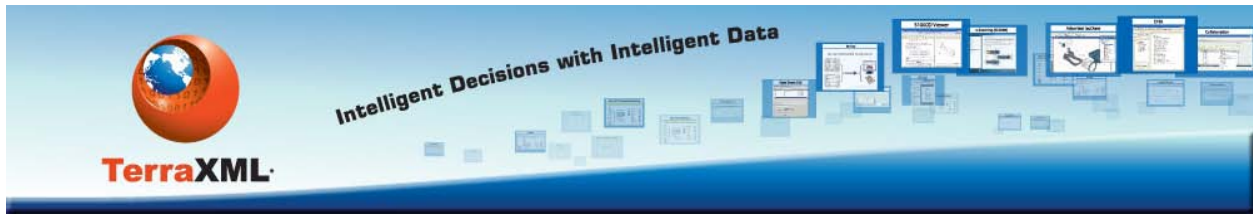
Your Values:



AMM DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
IPC DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
FIM DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
GMM DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
WDM DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
SRM DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
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??? DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
??? DC = _____ (SC) x _____ (NR) x _____ (NC) x _____ (NF) = _____ per year
Total Distribution Costs of all Manuals _____ per year

Printing Cost Savings Worksheet (example)	Min	Max
Current Situation		
Total annual costs of printing (Direct Costs)	\$ 135,500	\$ 135,000
Annual labor costs to receive and process docs (Productivity)	\$ 50,000	\$ 50,000
Total current annual costs	\$ 185,500	\$ 185,000
Estimated Improvement with TerraMRO		
% reduction in print direct costs	80%	100%
% Reduction in labor in handling document packages	25%	50%
Potential Benefits		
Annual savings in reduced postage costs for packages (Direct)	\$ 108,400	\$ 135,000
Annual savings in reduced labor costs for packages	\$ 12,500	\$ 25,000
Total annual savings in reduced print handling costs	\$ 120,900	\$ 160,000

Translation Cost Savings Worksheet (example)	Min	Max
Linked Input Page Values		
Costs paid to outside vendor for DTP	\$ 9,000	\$ 12,000
Costs paid to outside vendor for Word Count	\$ 21,000	\$ 28,000
Hourly cost of Technical Publications personnel	\$ 55.00	\$ 55.00
Current Situation		



Total cost of external documentation (computed from above)	\$ 30,000	\$ 40,000
Estimated Improvement with TerraMRO		
% reduction in word count through re-use of content	15%	20%
% reduction in DTP costs	90%	95%
Total annual savings in external documentation (computed)	\$ 11,250	\$ 17,000

ABOUT TERRAXML AND TERRAMRO

TERRAXML

TerraXML is a software product and professional services company focused on providing Product Life cycle Management (PLM), content management, and publishing solutions to corporate and government clients. Clients rely on TerraXML for its customer focus approach and expertise in PLM and Dynamic Publishing to solve complex business challenges. Worldwide office locations include headquarters in Boulder, Colorado and Beijing, China and regional offices throughout the United States. Visit TerraXML at <http://www.terraxml.com>.

TERRAMRO

TerraMRO™ has been developed as an enterprise-wide document management and change management solution for the MRO business to manage all the intellectual capital and provide global access to it in a secure and personalized environment using the included TerraView™ web portal. TerraMRO™ provides a single repository to house all the OEM, operator, and regulatory agency information, including reference manuals, engineering drawings, engineering orders, Job Cards and Work Packages, illustrated parts lists, service bulletins, safety notices, as well as company specific documents.