

Development Process and Training for Contribution to Aftermarket MRO Validation Process in the Aerospace Industry

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Abstract — *The Maintenance, Repair, and Overhaul (MRO) sector in the aerospace industry is crucial in ensuring aerospace systems' operational safety and efficiency. Training and methods for new and old teams on the aftermarket MRO processes is missing. This research addresses this missing training and methods by improving the validation process for aftermarket MRO by thoroughly examining the required knowledge, skills, and competencies. Utilizing the DMAIC (Define, Measure, Analyze, Improve, Control) methodology, the study investigates the current development processes and training methodologies and recommends improvement. An analysis of 28 repair requests revealed significant issues with incomplete documentation and inadequate training, leading to high rework rates and inefficiencies. By implementing a comprehensive training program and standardized procedures, the research achieved a notable reduction in the rework of the request.*

Key terms: *Aerospace, Aftermarket Processes, DMAIC, Efficiency, MRO, Training, Validation Process.*

PROBLEM STATEMENT

The aerospace industry's Maintenance, Repair, and Overhaul (MRO) sector is crucial for ensuring the safety, reliability, and performance of aerospace components and systems throughout their operational lifecycle. Despite the significance of the repair process, there is a recognized gap in the structured development repair process, information, and methodology for Aftermarket MRO in the aerospace industry. Current training methodologies may need more comprehensive coverage of the

intricate repair techniques, advanced tools, and evolving technologies pertinent to the industry. As a result, there is training that can be contributed directly to the aftermarket MRO validation process, which provides skills and knowledge to execute aftermarket MRO tasks efficiently and in compliance with industry standards.

RESEARCH DESCRIPTION

A critical component of the MRO sector is the aftermarket validation process. This study is important because it will contribute to improving personnel's capabilities, knowledge, and overall expertise in the process. It will also reduce returns, preparation time, and procedure errors. This minimizes the need for revision in the future and improves techniques in the process.

RESEARCH OBJECTIVES

This project aims to identify the specific knowledge, skills, and competencies required for professionals contributing to the Aftermarket MRO validation process in the Aerospace industry. To analyze current development processes and training methodologies and identify gaps and shortcomings in addressing the specialized needs of professionals involved in Aftermarket MRO validation. Different types of training or guidelines should be recommended to improve the process.

RESEARCH CONTRIBUTIONS

A comprehensive understanding of the specific knowledge, skills, and competencies required for professionals contributing to the Aftermarket MRO validation process in the Aerospace industry. After finishing training and knowing guidelines,

additional contribution reduces the person-hours research to a more efficient and confident writing repair process ending with customer satisfaction.

LITERATURE REVIEW

During the decades, the aerospace industry has continued to grow and become modern. On these days, the airplane contributes too much to the diary life. This method of transportation can be used for different purposes, such as food, health, supply, vacations, supplements needed to live, and more. After the innovation of this method of transportation, it began to grow over the years, and with this, companies became more interested in society. Companies have started to design more efficient engines but, at the same time, need to perform and develop maintenance repair and overhaul (MRO). The development of MRO is critical for the functions of airplanes, and performing the repair instruction for aircraft [1] requires different knowledge, training, tools, and data to be created and validated with the regulatory agencies FAA and EASA [2]-[3] and additional quality management systems book [1].

During the development process, a repair can observe the collaboration and how the Reworks process, defined by [4], are “actions taken to bring a defective or nonconforming component into compliance with requirements or specifications,” affecting the process. The process begins with identifying the damage; the request can take time. The repair design engineer (RDE) understands the problem. Though the design repairs are expected to have unexpected situations, reworks that impact the project process, and missing critical information that can take weeks, some analysis can be used to determine the effectiveness of the process.

Before creating a repair, the first steps are receiving, disassembling, inspecting, and identifying the damage or imperfections [5]. After that, validating a repair for the aftermarket will begin. This process involves receiving the customer's request with the damaged component, as an RDE needs to identify the part; some parts can

be fans or Blades, LPC, HPC, Turbines, combustor chambers, tubes, exhaust, cases, etc. Then, understand what type of damage and process must be applied. To perform an effective and efficient Efficiency As described by [1], “Efficiency is the ability to produce an intended result in the way that results in the least waste of time, effort, and resources. Effectiveness is the ability to produce a better result that delivers more value or achieves a better outcome.”

The missing process and basic concept of aircraft engines make it difficult to achieve the repair efficiently, with less collaboration, and in less time. We will analyze the basic concept needed to develop a repair for this design project. Identify using the Six Sigma DMAIC tool [6]. Also, the required training must be identified to succeed when working in the MRO aftermarket repair process. The main idea is to get all the training, lessons learned, and tools to be more efficient when they develop a repair and get less rework and time and more customer satisfaction and savings. The main goal is to reduce the rework by 50 % of the return work and deliver more than 75% on time to the customer.

METHODOLOGY

Implementing this methodology will help identify and implement training and tools for validating a repair process. The DMADV is the tool used to determine the design and training for executing a Repair design process in the Aftermarket. This tool helps identify the areas that need to be focused on. It is divided into five parts: define, measure, analyze, design, and validate, which will be calculated in five steps.

This Design process consists of three parts: first, understanding the basic knowledge necessary to work in the aerospace industry; second, Identifying the part, process, and information of the requested task; and third, the process to complete a successful validation. A DMAIC tool is used to measure the analysis process and time of competition.

Part I: Basic Knowledge of the Aerospace Industry

This part consists of a review of the basic knowledge that is applied to the aerospace industry. Some of these are the GD&T interpretation, composite of materials, tools training, and substantiation of the process. These tools and training can reduce the time, less rework before starting a repair, and more understanding of what is working.

Part II: Identify the Requested Task's Part, Process, and Information

After the requests for the tasks are received, the first thing is to identify the part where it is located and its function. We must review the manual and existing databases for the identified part to ensure we have the necessary information. With that information, you can reject the task or request the information required before starting the repair process.

Part III: Process to Complete a Successful Validation

For this part, the idea is to implement a process using the tool DMAIC: Define, Measure, Analyze, Improve, and Control. The definition consists of the verification of the requested repair. On measure, we need to have all the necessary information to identify and process the next step. On the analysis, if it takes more time to verify, the information and process are adequate for repairing the part. The analysis needs to be improved and discussed with the expert management of the area or task leader for approval. Finally, the repair is ready for validation approval.

Define Phase

This step is to receive the customer's request and the part that needs to be repaired. Verify all the information and documents to process the request.

Measure Phase

This measure helps to identify where the most impact will be on the repair process.

Analyze Phase

This third phase is used to research the information given, analyze the part, and identify the potential of the repair. With the data, we can conduct more research to determine if there is a history of repair that helps with the analysis.

Improvement

This step identifies the tool and training the repair design engineer needs to perform the repair process with less rework on each validation step.

Control

This phase helps the engineer or company implement future training and processes that allow the engineering team to perform the task with fewer returns. The process and documentation are also standardized.

The methodology and training recommended to help the validation process are:

1. Training
 - a. GD&T training knowledge
 - b. Composite Material basic knowledge
 - c. Essential Structural durability and stiffness knowledge.
 - d. Finite Element Analysis (FEA).
2. Process
 - a. Request documentation needs to be complete and precise.
 - b. Research, identify the part, and discuss the information parts with the database. Identify the repair process that will be applied: templates and standard documentation.
 - c. Perform the repair and discuss it with the team leader.
 - d. Verify external disciplines that need to be evaluated in the repair process.
 - e. Validate the process.

RESULTS AND DISCUSSION

The outcomes of this research highlight the critical role that structured training and standardized processes, as guided by the DMAIC methodology, play in enhancing the efficiency and

effectiveness of the MRO validation process, ultimately contributing to improved operational safety and customer satisfaction in the aerospace industry.

Define Problem

After reviewing the repair process for a commercial engine component from February 2024 to September 2024, information was collected to create a process using the previous methodology. For RDE analysis, verify the time and tool needed to perform a repair. The new training program and standardized templates were crucial in reducing documentation errors and rework. The process begins with identifying the problem. Most commonly, the problem is the missing information, customer requests, and data provided. After receiving the task to start performing the repair, one needs to evaluate the part, the method, and the limits to perform.

This step is crucial to considering the request from the beginning and requesting verified information from the stakeholders. The following tables, using the DMAIC technique, show the percentage of the time that the request or process

was not followed by the standard or missed information.

Measure Problem

In the measurement process, 28 requests were considered. The percentage of tasks that require rework in each step can be seen in the following table (Table 1). These interpretations are before the process and training are implemented by the team.

Most of the rework is on the beginning request (received) and on the analysis, with the two highest percentages of rework (see Table 3). This is a cause of training and failure to follow the process.

Analyzed Process

The analysis process identifies five categories. These categories mention the focus on what needs to be improved on each one. The same can be found in the following table (Table 2). The first step can be categorized as the design and materials issues; this came with the requested information. The second step can include the process and equipment, and the third step is training and communication for an effective method.

Table 1
Percentage that the Design Process Request Needs Rework

Design steps	Problem identifies	Percentage of tasks without rework	Percentage of tasks need Rework
Received	Request problem for the customer. Missing data information. Time of response.	71.43%	28.57%
Analysed	Understand the method, process, and minimum requirement	14.29%	85.71%
Performed	Missing training, procedures, parts functionality	46.43%	53.57%
Design review	Communication between Disciplines, response, and process	35.72%	64.28%
Validate	Approved document without returns (rework)	53.58%	46.42%

Table 2
Design Process Causes on Each Step of the Process

Category	Causes
Design Issues	Missing information in the initial request
Materials	Incorrect material information used for specific repairs
Processes	Inconsistent repair procedures and workflow

Equipment	Outdated or malfunctioning repair tools and equipment. Insufficient Disciplines specialist
Training	Need for more training for repair technicians. Poor knowledge of material properties and Procedures
Communication	Poor communication and documentation update.

Table 3
This is Based on 28 Repair Requests

Metric	Rework before the process	Post-rework after implement training
Received	8	5
Analysed	24	17
Performed	15	12
Design review	18	15

Table 4
Percentage that the Desing Process Improve

Metric	Input Value of rework	Post-Improve Value	Change Improve
Received	28.57%	17.85%	10.72%
Analysed	85.71%	60.71%	25.00%
Performed	53.57%	42.85%	10.72%
Design review	64.28%	53.57%	10.71%
Validate	46.42%	32.14%	14.28%

Improvement

The focus of the process is to Develop and implement a new training program focusing on standardized documentation practices and knowledge. First, the new hires need to know the parts of the engines and their functions. After learning the parts, begin reading the drawings and training for Geometric Dimensioning and Tolerancing (GD&T), a necessary design and manufacturing tool.

The ASME Y14.5 GD&T is an industry-standard practice that provides guidelines on definitions, requirements, and recommended practices for design models and drawings [7]. The third crucial knowledge is familiarization with the process and methods of creating and validating a repair. Additional training and technical expertise, such as structural and metallurgy knowledge, are needed to repair. The Finite Element Analysis (FEA) is the standard tool for the structural view to simulate and analyze the part.

The metallurgy part provides the necessary information to determine whether the application and process can be performed on that material. The standardized documents and procedures give the Repair Development Engineer (RDE) more time to perform the repair efficiently and lower the rework at each step.

Control

Standardized templates for documentation to ensure consistency according to the regulations and approvals. Streamline the document review process by automating certain checks and reducing redundant steps. Continue updated SOPs and training to reflect new documentation practices and integrate these changes into training materials.

Set up a dashboard to track key metrics such as rework rate and cycle time. Also, regular reviews should be established to ensure adherence to new practices.

DISCUSSION

The implementation of the DMAIC methodology significantly improved the MRO validation process, particularly in the areas of documentation accuracy and process efficiency. The following table (Table 4) presents observations and insights noted after implementing training and procedures for another 28 requests. Table #3 represents the number of request steps that have been reworked. Values are based on 28 requests before and after implementing some training and standards processes. During the analysis, we see an improvement of 25% when implementing the necessary training to understand the repair process.

CONCLUSION

Applying the DMAIC methodology to the Aftermarket Maintenance, Repair, and Overhaul (MRO) validation process has identified the areas that need improvement, which was essential and thriving during the research and documentation for the aerospace industry. The approach allowed for a comprehensive assessment and systematic enhancement of the MRO validation process, resulting in the improvement of reduced rework on the process in each step from 10 to 25 percent for each metric process see Table 3.

FUTURE RECOMMENDATIONS

In conclusion, applying the DMAIC methodology has met expectations and offered a robust model for future process enhancements and a stronger foundation for maintaining high standards in aerospace MRO validation, so there is always room for further refinement. Future efforts could focus on expanding the scope of improvements to other areas of the MRO validation process and exploring additional training and processes to implement. Communicate with the team to identify opportunities in different departments and regions.

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