Identification of Contributing Factors Impacting Aircraft Engine Component Repair Instructions Development

Author: Wilmaris Marcano Cruz
Advisor: José A. Morales Morales, PhD
Manufacturing Engineering – Quality Management, Graduate School

Abstract

The development of repair instructions for aircraft engine components is complex and exposed to errors during development, affecting the completion and delivery on a timely manner. The purpose of this project was to identify contributing errors affecting the technical data development for a specific aircraft component family, categorize them and identify main offender. Three different databases were reviewed to collect findings, focusing on active tasks from March 2022 to October 2022. Findings collected on each database were aligned into five categories directly related to the technical document development: Background Research, Preliminary Design Review, Repair Substantiation, Final Design Review and Final Validation. The Background Research category was found to be the main area of opportunity, with thirteen findings out of a total of thirty (43%). Two initiatives were implemented to mitigate risks: controlled list of part numbers and documented best practices shared among team members.

Introduction

The Aerospace industry is a vast network of companies and individuals spanning across the globe. Our daily life is tied to this industry, be for defense for the military, transportation or supply chain and logistics dependent on air travel, which impact the deliveries of mail, food, clothes, and other articles. To keep the industry flowing smoothly on both military and commercial sectors, aircraft maintenance is vital. Every aircraft component has a function and specifications. Parts are inspected against a set of instructions specific to each part. The process to create instruction repair documents is the focus of the project.

Background

Throughout the development of the repair instructions, it is noted that reworks are raised. Reworks [1] are "actions taken to bring a defective or nonconforming component into compliance with requirements or specifications". The project engineer studied the process of the stages of a repair instruction development to review where waste [2] and rework cycle [8] were impacting the process, to also confirm if Background Research was the cause of half of the reworks, as hypothesized.

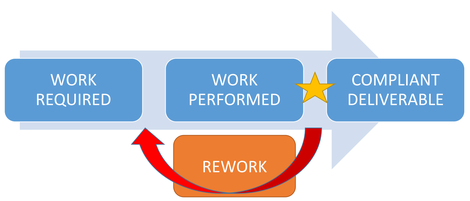

Figure 1: Rework Flow

Objectives

- Identify categories of major offenders contributing to repair instructions findings and reworks.
- Breakdown of main categories affecting the end-product into sub-categories and review project engineer's hypothesis that Background Search is the main contributor to reworks.
- Identify possible solutions to minimize major offenders.
- Document risk mitigations implemented during the results and discussion phase of this project.

Methodology

Data gathering and analysis was performed in three phases:

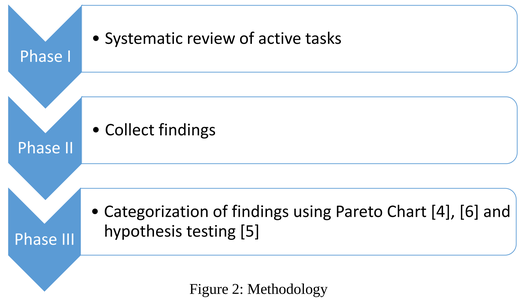

Figure 2: Methodology

Hypothesis: "Background Research would be the main offender in the process, with 50% of the defects, with a confidence level of 95%."

- Null Hypothesis (H0): μ = 50% of defects are related to Background Research
- Alternative Hypothesis (Ha) = 50% of defects are not related to Background Research

Results and Discussion

Active tasks for the specified timeframe were reviewed, findings identified and categorized, per the established methodology. To address the hypothesis testing, applying the chi-square distribution approach, with a significance level (α) of 0.05, equations (1) is required for the degrees of freedom and (2) for the chi-square:

$$Degrees\ of\ freedom = df = n\text{-}1 \qquad (1)$$

Considering five categories identified, $df = 4$.

$$Chi\text{-}Square = x^2 = \Sigma((o\text{-}e)2/e) \qquad (2)$$

o = *observed value*
e = *expected value*

Considering observed and expected values for all five categories, the result for (2) is:

$$x^2 = (13\text{-}15)^2/15 + (7\text{-}3)^2/3 + (7\text{-}6)^2/6 + (0\text{-}4)^2/4 + (1\text{-}2)^2/2$$
$$x^2 = 10.2667$$

The first value over 10.2667 in a chi-square distribution table [7] is 11.14, and p-value equals 0.025. So, 'p' is between 0.025 and 0.05, which is less than the significant level of 95%, hence the null hypothesis is rejected.

Results and Discussion (cont.)

Though not 50% of findings are related to Background Research as hypothesized by the projected engineer, certainly this is the category with more reworks identified, with thirteen out of thirty findings (43%).

Table 1: Number of Findings per Task and Category

Task ID	Component Type	Background Research	Preliminary Design Review	Repair Substantiation	Final Design Review	Final Validation	Total Findings
T352-105SEC	Ring					1	1
T352-106EC	Seal	1					1
T352-111EC	Plate	1	1	1			3
T352-130EC	Ring	2	1	1			4
T352-137EC	Box	2					2
T352-142EC	Duct	2	1	1			4
T352-145EC	Case	1					1
T352-37EC	Duct	1	1	1			3
T352-76EC	Case	1				1	2
T352-80SEC	Assembly	1				1	2
T352-88EC	Holder		1				1
T355-137EC	Liner			1			1
T355-150EC	Liner	1	2	2			5
Total	-	13	7	7	0	3	30

Table 2: Background Research Findings Count

Background Research	Count	Weight (%)
Affected Part Numbers Selection	5	38
Team Meeting for Task Review	3	23
Understanding of Distress	2	15
Repair Constraints	2	15
Reference Projects Study	1	8

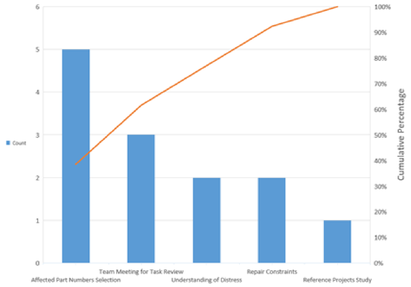

Figure 3: Background Research Findings per Activity

Table 3: Suggested Solutions to Minimize or Eliminate Major Offenders Related to Background Research

Major Offenders	Count	Suggested Solution(s)
Affected Part Numbers Selection	5	• Centralized and controlled live document with component part type part numbers per configuration • Detailed review of active and nonactive parts prior task kickoff to ensure proper applicability
Team Meeting for Task Review	3	• Enforce a new team meeting whenever a team member changes, to align task understanding
Understanding of Distress	2	• Repair engineer to engage with part family lead early in the background research process to review and discuss causes of the damage on the component(s). This is standard process but may need further encouragement from team to perform.
Repair Constraints	2	• Repair engineer to engage with part family lead early in the background research process to review and discuss causes of the damage on the component(s) and applicable and nonapplicable repair approaches. This is standard process but may need further encouragement from team to perform.
Reference Projects Study	1	• Document early in the repair development process applicable history of repairs in the component area that could be use as reference to develop the new document. This is standard process but may need further encouragement from team to perform.

Mitigations implemented (as they are in control of the project engineering team):

- Centralized and controlled live document with component part type part numbers per configuration created.
- List of best practices for repair tasks management created and shared across all project engineers, repair engineers and part family leads.

Conclusions

1. Findings leading to reworks are not uniformly documented.
2. The Background Research portion of the repair instruction development is the major reason for reworks, specifically during the affected parts identification. Addressing this area would eliminate up to 43% of the findings.
3. There is a possibility to implement other mitigations to reduce or eliminate errors dependent of other departments or functions outside of the project engineering organization and improve effectiveness in the process [3].

Future Work

The exercises performed for this specific aircraft component part family could be also performed in the rest of the component families (modules) for the whole engine program, to provide a comparison of all families and show if the Background Research process is the main offender in other modules as well. Further study would be ideal to capture time wasted and cost associated to the rework. At this stage, this information cannot be obtained with certainty, as there is missing information as actual time taken per rework , who corrected the mistake, among others.

Acknowledgements

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