Identification of Contributing Factors Impacting Aircraft Engine Component Repair Instructions Development

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Abstract — *The development of repair instructions for aircraft engine components is complex and vulnerable 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 the 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 distributed 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 13 findings out of a total of 30 (43%). Two initiatives were implemented to mitigate risks: controlled list of part numbers and documented best practices shared among team members.*

Key Terms — *Aerospace, aircraft engine components, quality, rework.*

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 it for defense from the military, transportation or supply chain and logistics dependent on air travel, which affect the deliveries of mail, food, clothes, and other items. 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.

OBJECTIVES AND RESEARCH CONTRIBUTIONS

The intention of the project was to identify the major challenges being encountered during the development of repair instructions for aircraft engines components.

The objectives are:

- 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.

As highly technical and time-consuming activities are involved in the creation of the instructions, the contributions are identifying areas of opportunity to improve quality and efficiency to affect the flow of work and minimize findings or reworks prior or after the presentation of the end-product. Also, the identification of solutions and opportunities to implement risk mitigations to avoid errors during process. The areas explored in this project are the ones where the assigned project engineer interacts and can affect the process, though opportunities on other steps of the process owned by different team members are collected as well.

LITERATURE REVIEW

The development of repair instructions for aircraft engine components requires different stages and support functions to review facts, gather technical information on the part and observed distress, prepare technical documents and references, validate the information, and have the information published and delivered to the end customer or users. Each repair instruction is considered a deliverable. Though all tasks follow a standard approach for background exploration, guidelines to select repair methods and applicable standards, document template and review procedures, each task has its own requirements, complexity, and schedule. Team members may vary and have different projects active at the same time.

Defects on aircraft engine components are identified by a team working with the actual parts on the field or by engineering teams performing predictive analysis on the behavior of the engine and components. Once it is agreed that a repair is to be developed to address an actual field finding or as a solution for an expected incoming distress, the component the part family lead defines the task requirements, and a repair engineer will collect any previous history on similar defects on the part and other background information. With the project engineer, the expected external support required from outside organizations is identified and expected timeline to complete the project is baseline. The end-product is a technical, controlled document published in the approved system platform for users to access.

Throughout the development of the repair instructions, it is noted that errors or reworks are raised. Reworks, as defined by [1], are "actions taken to bring a defective or nonconforming component into compliance with requirements or specifications". Though all projects are expected to have space in the schedule to account for unexpected situations, reworks impact the project process, be that it takes a few minutes to fix, or the rectification takes weeks, which tapping into Lean concepts, is a Waiting waste [2] to avoid.

What are, on a high level, the challenges being observed in the repair instructions development process that seem to contribute to defects and reworks? Starting from the define phase of the repair task, affected part numbers for a component configuration may be missing. Depending on the component, different versions may be active in the field at the same time, so the repair being developed must specify if it applies to all active versions or specific ones. This is like car recalls, where the manufacturer on the recall notices to customers specifies the car models affected. In this phase as well, the need of support functions may not be immediately clear and called in to the project late. Examples are the necessity to develop a tool to support the repair operation. A different team, with their own projects and schedules, needs to be made part of the project team and allow them time to assess the project requirements and maintenance steps to identify an existing tool that can support the task or design a new tool concept. This activity can add from six to eighteen months to the project.

Another activity that can impact the deliverable is the feedback processes with the Validation team during the development phase. This team goes over the repair document a few times before it is to be sent for departmental approvals and final publication. It is expected to have a few iterations with Validation to correct or clarify content, which is accounted on the schedule. Some examples are missing or unclear graphics, missing substantiation on selected cleaning or treatment processes and unclear or complicated repair steps. Certainly, capturing possible escapes and avoiding publication errors is part of the review process prior publication and help maintain the expected quality standards. Still, frequent findings put a delay into the publication and can cause further complications into the main program plan for the component.

Lean Six Sigma concepts, as efficiency and effectiveness, can help streamline the challenges towards improvements. As described by [3], "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, one that delivers more value or achieves a better outcome."

At first hand, from a project engineering standpoint, efficiency should be the north in the path to improve the repair instructions development process. The team wants to deliver the product in the least amount of time, avoiding unnecessary efforts and least use of resources (people and budget, for example). Still, it may be for this case that in the quest to be efficient many tasks are tackled at the same time across different projects, prompting errors.

In real-world efficiency, it will be side by side or more regarded than effectiveness, depending on the organization, though the later pursues minimization of findings and reworks by delivering a consistent, conforming product if it has as base the correct base. Therefore, it is important to collect and classify findings to study actions to implement to avoid common errors and help the development process run more smoothly. A tool for this purpose is the Pareto Chart, which shows the frequency of defects or unwanted occurrences, and the cumulative data percentage in a rank-order which helps the segregation of root causes [4] impacting the repair instructions development process, and "separate the vital few from the useful many" [2]. This chart is one many quality tools that facilitate understanding of data behavior and facilitate the visualize areas to improve within a process [5], [6].

A limitation for this research is that some of main offenders or root causes linked to reworks are outside of the area of control of the project engineer, or dependent on other functions, which can affect implementation of solutions and/or risk mitigations to be explored in this document.

Methodology and Scope of Research

Three phases of data gathering, and interpretation were used. The first one was a systematic review of repair instructions development for active tasks from March 2022 to October 2022 in a specific engine component family area. The second phase was to collect all reworks identified during the development process of the repair. The last phase was to categorize the findings per similarity (as happening due to the same data source, lack of information, availability of resources, among others).

Phase I: Systematic Review of Active Tasks

This phase consists of a review of all active tasks on a specific engine component family area. The source for information and quantification of active tasks on this search will be the component family project engineer.

Phase II: Collect Findings Identified on Active Tasks

After the active tasks for the selected period were identified, a review of reworks related to each task was performed, mostly by going through the project communications and meetings' notes, collecting feedback from team members and a review of existing databases. On the database portion, information may not had been necessarily uploaded at the time of the review due to task being active still or findings do not fall on the existing database categories, hence not collected by the team. Some tasks did not have findings documented due to not having errors to correct, or possibly practitioners not documenting the findings.

Phase III: Categorization of Findings

Categorization of findings is imperative to understand the main areas needing support and improvement. The categories identified were dependent on the type of findings observed. A count of findings per category to identify the major offender(s) was performed, and a hypothesis test from the project engineer standpoint reviewed.

Results

A review of aircraft engine repair instructions for a specific engine component family, active in development for the period of March 2022 to October 2022, has been performed and analyzed using the methodology established previously. The registry of the assigned project engineer was used to confirm eighteen tasks were active during the selected period.

Table 1 shows the reference tasks used to study major offenders contributing to during the repair instructions development during the March 2022 to October 2022 timeframe. Each task has a unique identifier, and the table also shows the part related to the task, as understanding the area of the component family affected can later help identify specific challenges when working each part.

Table 1
Active Repair Development Tasks for March-October 2022

No	Task ID	Component Type
1	T352-103SEC	Liner
2	T352-105SEC	Ring
3	T352-106EC	Seal
4	T352-111EC	Plate
5	T352-127EC	Ring
6	T352-130EC	Ring
7	T352-137EC	Box
8	T352-142EC	Duct
9	T352-144EC	Case
10	T352-145EC	Case
11	T352-146EC	Box
12	T352-37EC	Duct
13	T352-76EC	Case
14	T352-77EC	Case
15	T352-80SEC	Assembly
16	T352-88EC	Holder
17	T355-137EC	Liner
18	T355-150EC	Liner

Collecting Findings for Active Tasks

Different approached were used to collect findings related to reworks on the tasks. The first approach was a review of the Quality database of the site used by all team members to search any entries related to the tasks shown on table 1. This database is the official company tool to collect and track findings, with the intention of been a centralized and accessible tool to employees. The categories in the Quality database related to the repair instructions development process are Background Research, Preliminary Design Review, Repair Substantiation, Final Design Review and Final Validation. Of the eighteen tasks, two appeared in the Quality database: task T352-105SEC with one entry, and task T352-76EC with two.

The second approach was to review a database kept by the part family leads (PFLs), which is a file not accessible for the rest of the team. The purpose of this database is to collect data on active repair development tasks and identify the density at specific steps of the review process, be task preparation, design review or other. The categories in this PFL database related to the repair instructions development process are Preliminary Design Review, Repair Substantiation. Final Design Review and Final Validation. Noted that this database combines the background search or task preparation activity within the Preliminary Design review, unlike the company Quality database. With this information, the leads identify areas of improvement to flow down to engineering level for application. After reviewed, four entries related to the tasks studied on this project were found. Affected tasks are T352-106EC, T352-130EC, T352-80SEC and T352-137EC. It is already noted that this PFLs database is not connecting to the main company Quality database as the identified task IDs are not the same in the platforms.

The last approach to identify findings related to the subject tasks by performing a review of each tasks' project communications and meeting notes. Though informal, studying if any of these notes was captured by any team member into the databases (either the official Quality one or the PFLs') helped check if there was a tendency to leave out specific findings from the databases and understand if the team sees findings in the same light (what is feedback and what is an actual item to capture and check to resolve and share the learnings). Given that there is no defined category to collect findings on project communications and/ or meetings notes, findings were identified as any action collected that required any team member to revise, correct or add information to the task. As noted previously, as with the dynamics between the Quality and PFLs' databases, findings raised in project communications and/ or meetings notes may not be transferred to either database or a task may have an entry in two of the three approaches taken, but the entries not related between them.

Of the eighteen tasks in the list, nine have some type of finding or rework recorded in meeting notes and or general email communications. Only tasks T352-130EC, T352-76EC and T355-150EC have findings identified in at least two approaches, though not due to the same issue. Table 2 shows a comparative list of the active tasks from March 2022 to October 2022 with a finding registered in either database, or in project communications. Note that table 2 only shows where a finding was noted, not a count of issues per findings, as one entry can describe two issues or more issues within the same task. It is also noted that five tasks have no registry of findings at all.

Categorization of Findings

For this effort, five tasks with no identified issues were removed from the data. To align issues collected using the three approaches described in the previous section, the Quality database categories will be used to distribute the findings. Table 3 shows the categories used to segregate the findings for affected tasks, and the database from where they were collected. Thirteen tasks are found to have some type of issue in the completion of its' repair instructions. Table 4 shows tally per task and category. Thirty findings were segregated into categories.

The hypothesis from the project engineer was that 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

Applying the chi-square distribution approach [2], with a significance level (α) of 0.05, equation (1) is required for the degrees of freedom and equation (2) for the chi-square:

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

Considering five categories identified, $df = 4$.

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

o = observed value
e = expected value

Table 2
Review of Existing Database and Records to Identify Collected Findings per Task

No	Task ID	Component Type	Databases		
			Quality	PFL	Notes and Meetings
1	T352-103SEC	Liner			
2	T352-105SEC	Ring	X		
3	T352-106EC	Seal		X	
4	T352-111EC	Plate			X
5	T352-127EC	Ring			
6	T352-130EC	Ring		X	X
7	T352-137EC	Box			X
8	T352-142EC	Duct			X
9	T352-144EC	Case			
10	T352-145EC	Case			X
11	T352-146EC	Box			
12	T352-37EC	Duct			X
13	T352-76EC	Case	X		X
14	T352-77EC	Case			
15	T352-80SEC	Assembly		X	
16	T352-88EC	Holder			X
17	T355-137EC	Liner	X		
18	T355-150EC	Liner		X	X

Table 2
Breakdown of Findings per Category

Task ID	Component Type	Background Research	Preliminary Design Review	Repair Substantiation	Final Design Review	Final Validation
Quality Database						
T352-105SEC	Ring					X
T352-76EC	Case	X				
T355-137EC	Liner			X		
PFL Database						
Task ID	**Component Type**	**Background Research**	**Preliminary Design Review**	**Repair Substantiation**	**Final Design Review**	**Final Validation**
T352-106EC	Seal	X				
T352-130EC	Ring	X	X	X		
T352-80SEC	Assembly	X				X
T355-150EC	Liner	X	X	X		
Notes and Meetings						
Task ID	**Component Type**	**Background Research**	**Preliminary Design Review**	**Repair Substantiation**	**Final Design Review**	**Final Validation**
T352-111EC	Plate	X	X	X		
T352-130EC	Ring	X				
T352-137EC	Box	X				
T352-142EC	Duct	X	X	X		
T352-145EC	Case	X				
T352-37EC	Duct	X	X	X		
T352-76EC	Case	X				X
T352-88EC	Holder		X			
T355-150EC	Liner	X	X	X		

Table 4
Total 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

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

$$x^2 = (13-15)^2/15 + (7-3)^2/3 + (7-6)^2/6 + (0-4)^2/4 + (1-2)^2/2$$

$$x^2 = 10.2667$$

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 the next greater value on the table) which is less than the significant level of 95%, hence the null hypothesis is rejected.

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 among ten tasks reporting some problem in this area. The issue is more prominently identified on the project notes, which come from discussions with the team members and not seemed to be transferred to the Quality database to share the issue, learnings, and conclusions.

Background Research is divided among five steps: understanding distress, reference previous projects, select affected part numbers, team meeting review of task and review of repair constraints. Table 5 shows the breakdown of Background

Research, with the count per finding and weight related to it to. Figure 1 shows how the findings for Background Research divided in its activities in Pareto form, with the selection of affected part numbers being the major issue with a count of five. Each component type may have different part numbers related to it.

Table 5

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

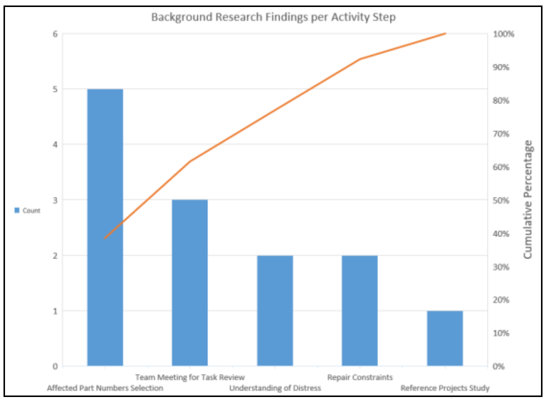


Figure 1

Pareto chart for the Background Research's most common findings. "Affected part numbers selection" is the biggest offender with a 38% cumulative percentage.

For the ten tasks contributing to the Background Research findings, it is noted that all tasks were created six to twelve months or more prior the active period of March 2022 to October 2022, with most (if not all) team members not being part of the original team that kicked off the projects. This may be common for undergoing tasks due to the amount of workload to process prior managing a task and/ or stoppage to work on other priorities. 'Team meeting for task review' is the second major offender on the Background Research and may be directly impacted to this gap between starting a start and finishing it. For the ten tasks referenced, only three had a scheduled team meeting after a period of inactiveness or changes in the team members (engineer, part family lead or other).

To explore deeper into the common findings, the "Preliminary Design Review" and "Repair Substantiation" categories findings were combined, and issues segregated. Fourteen findings are flagged (seven each) among seven tasks. These two categories are worked closely together. Combining them for the sake of understanding behavior trends may prompt ideas to also minimize or eliminate other issues. Preliminary Design Review is broken down into "Repair Approach" and "Graphics and Illustrations". Repair Substantiation is broken down into "Structural Analysis" and "Groundwork Information". Table 6 shows the findings for these two processes, noting Repair Approach as the biggest hitter. This category includes the initial selection of the repair method and its steps (such as disassembly steps, visual inspections, among others) and can detour the repair progress if incorrect data is used at the time of the Final Design Review and/ or Final Validation steps. Figure 2 shows the combined findings for Preliminary Design Review and Repair Substantiation.

Table 6

Findings Count Between Preliminary Design Review and Repair Substantiation

Preliminary Design Review	Count	Weight (%)
Repair Approach	7	50
Structural Analysis	4	29
Groundwork Information	2	14
Graphics and Illustrations	1	7

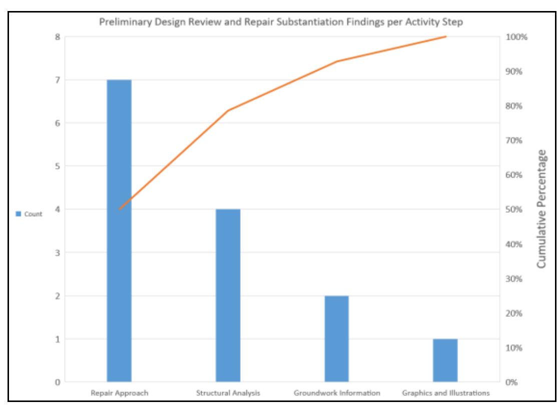


Figure 1: Pareto chart for the most common findings when combining Preliminary Design Review and Repair Substantiation. "Repair approach" is the biggest offender with a 50% cumulative percentage.

RESEARCH OBJECTIVES FULFILLMENT AND CONCLUSIONS

The first two research objectives were addressed using the methodology described.

- Identify categories of major offenders contributing to repair instructions findings and reworks, shown in table 3.
- Breakdown of main categories affecting the product into sub-categories, shown in table 5.

The third objective is addressed in table 7, where a list of possible solutions to minimize (or eliminate) quality findings during the aircraft engine component repair instructions development process during the Background Research is shown. Other possible mitigations, as updating the Standard Work or further technical knowledge development of the team are outside the control of the project engineer. These may help minimize or eliminate other errors, as the repair approach issues noted on table 6. If the Background Research findings are addressed, for a future sample of tasks outside the timeframe selected for this project, up to 43% of the findings would be eliminated.

The fourth and last objective is to document risk mitigations implemented during the results and discussion phase of this project. At the time of the creation of this article, the following mitigations have been implemented, as they are in control of the project engineering team.

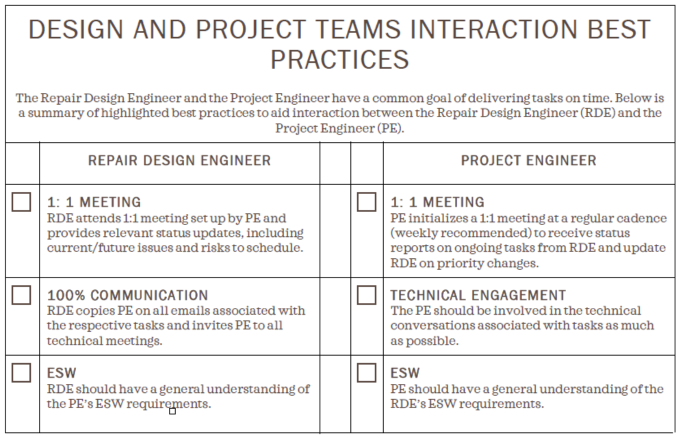
- Centralized and controlled live document with component part type part numbers per configuration created, and under the ownership of the part family lead.
  - Currently used on active tasks from March 2022 to October 2022 not yet at the approval cycle. This prevents creating a revision for the published document for corrections. Table 8 shows an extract of the part number centralized document and the existing configurations.
- List of best practices for repair tasks management created and shared across all project engineers, repair engineers and part family leads. A redacted extract of the document is shown in figure 3. The best practices include:

Table 7
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.

Table 3
Part Number Configuration Control per Part Type

	Part Numbers per Configuration				
Component Type	Domestic	Domestic CR	Domestic WC	TTI	TTI WC
Assembly	41-35ASD	41-35ASCRD	41-35ASWC	41-35ASTTI	41-35ASTTIWC
Outer Case	41-35RSROCD	41-35RSROCRD	41-35RSROCWC	41-35RSROCTTI	41-35RSROCTTIWC
Inner Case	41-35RSRICD	41-35RSRICRD	41-35RSRICWC	41-35RSRICTTI	41-35RSRICTTIWC


DESIGN AND PROJECT TEAMS INTERACTION BEST PRACTICES

The Repair Design Engineer and the Project Engineer have a common goal of delivering tasks on time. Below is a summary of highlighted best practices to aid interaction between the Repair Design Engineer (RDE) and the Project Engineer (PE).

	REPAIR DESIGN ENGINEER			PROJECT ENGINEER
☐	1: 1 MEETING RDE attends 1:1 meeting set up by PE and provides relevant status updates, including current/future issues and risks to schedule.		☐	1: 1 MEETING PE initializes a 1:1 meeting at a regular cadence (weekly recommended) to receive status reports on ongoing tasks from RDE and update RDE on priority changes.
☐	100% COMMUNICATION RDE copies PE on all emails associated with the respective tasks and invites PE to all technical meetings.		☐	TECHNICAL ENGAGEMENT The PE should be involved in the technical conversations associated with tasks as much as possible.
☐	ESW RDE should have a general understanding of the PE's ESW requirements.		☐	ESW PE should have a general understanding of the RDE's ESW requirements.

Figure 2
Extract of the Best Practices Document for the Repair Tasks Management between Repair and Project Engineers

- The project engineer to understand the Standard Work to develop and publish a repair instruction document.
- Repair engineer to communicate issues and risks early, to engage project engineer and part family lead.

The research has addressed the objectives posed and obtained the following conclusions:

- Findings leading to reworks are not uniformly documented, as two separate platforms are used (company's Quality database and PFL database), plus other findings are not officially documented in only tracked via email or meeting minutes.
- The Background Research portion of the repair instruction development is the major offender for reworks, specifically during the affected parts identification. Addressing this area would eliminate up to 43% of the findings for the sample tasks in the selected timeframe.
- 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].

Summary of Contributions

Understanding the major offenders for the specific aircraft component family repair instructions development will provide the team insight into areas to improve and engage. Discussions of areas of opportunities do need to have data as backup, to not just go after items 'we feel' need to improve but are impacting performance and delivery. With this exercise, it has been shown the Background Research process needs attention, and there is now a developed and controlled list of part configurations engineers can refer to and discuss with the part family lead to capture the correct affected parts.

Future Research

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. This would provide a comparison of all families and show if the Background Research process is the main offender in other modules, or other areas require attention depending on the component. It would also show the management of findings. Are other modules using the company Quality database, or other method? This could be answered by expanding the research to the whole engine program.

The count of findings was tabulated, though further expansion of the tabulation would be ideal capture time wasted and cost associated to the rework. At this stage, this information cannot be obtained with certainty, as there is missing information per task, such as the actual time it took to rework a document, who corrected the mistake, among others.

REFERENCES

[1] *A Guide to the Project Management Body of Knowledge: PMBOK Guide*, 4th ed. Newtown Square, PA: Project Management Institute, 2008.

[2] J. M. Juran and J. A. De Fep, “Methods and tools: what to use to attain performance excellence,” in *Juran's Quality Handbook*, 6th ed., New York: McGraw-Hill. 2010, pp. 327-438, 612.

[3] M. Wooll, “Still chasing efficiency? Find out why effectiveness is a better goal,” BetterUp, March 16, 2022, [Online]. Available: https://www.betterup.com/blog/efficiency-vs-effectiveness.

[4] T. Hessing, “Pareto Chart (Pareto Diagram),” in *Six Sigma Study Guide* [Online]. Available: https://sixsigmastudyguide.com/pareto-chart/.

[5] C. Ortega, “Análisis predictivo: qué es y cómo implementarlo,” in *QuestionPro* [Online]. Available: https://www.questionpro.com/blog/es/analisis-predictivo/.

[6] Gemba Academy, *Learn What the 7 Quality Control Tools Are in 8 Minutes*, Sep. 25, 2010. [Video file]. Available: https://www.youtube.com/watch?v=LdhC4ziAhgY.

[7] S. Turney, “Chi-Square (X^2) Table | Examples & Downloadable Table,” in *Scribbr*, November 10, 2022. Available: https://www.scribbr.com/statistics/chi-square-distribution-table/.