Enhancing Field Issue Resolution Workflow for Compressor Components

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Abstract *— Field investigations of compressor components are essential to maintaining aircraft engine reliability and fleet availability, but investigation closure times are often extended due to incomplete intake data and sequential engineering coordination. This study evaluates compressor component investigation workflows within a centralized aerospace engineering support organization and develops process improvements using Agile engineering management principles. A baseline review of four representative investigation cases, supported by stakeholder interviews and workflow mapping, identified primary delay drivers and coordination challenges. Improvement initiatives were implemented through two Agile sprints focusing on intake data standardization and workflow execution efficiency.* The improvements were integrated into a future-state workflow model incorporating mandatory intake checklists, parallel multidisciplinary engineering assessments, early quality and safety engagement, and centralized investigation tracking. The proposed workflow is expected to reduce investigation closure time by approximately 25 to 35% while improving communication efficiency and technical consistency. The results demonstrate the effectiveness of Agile methodologies in improving multidisciplinary aerospace investigation workflows.

Key Terms *— Agile engineering management; Aerospace field investigations; Maintenance, repair, and overhaul (MRO); Process standardization*

INTRODUCTION

Field investigations of aircraft engine components are essential to maintaining fleet safety, operational availability, and regulatory compliance. Compressor components operate under extreme thermal and mechanical loads and are frequently involved in service events such as cracking, erosion, foreign object damage, and kinematic malfunctions. These investigations are typically conducted within centralized aerospace engineering support organizations that coordinate multidisciplinary engineering teams, customer support groups, quality and safety departments, and external maintenance providers.

The project was conducted within the context of a large aerospace engine manufacturing and maintenance, repair, and overhaul (MRO) environment supporting both military and commercial fleets. In this environment, engines were deployed globally and maintained by operators and depot-level maintenance organizations, while technical investigations were led by a centralized engineering support organization. This organization coordinated multidisciplinary engineering teams, customer support groups, quality and safety departments, suppliers, and program management to evaluate in-service events and define corrective actions.

Within this operational setting, compressor components represent high-risk hardware due to their influence on engine performance, structural integrity, and mission readiness. Failures in these components can result in aircraft groundings, operational limitations, and increased logistics costs, making timely investigations critical to restoring serviceability.

Despite the technical expertise available within the organization, investigation closure times often extended to several months. Previous cases showed that delays were not primarily driven by analytical complexity alone, but by incomplete initial data, repeated clarification cycles, sequential engineering reviews, and limited visibility across stakeholders. These inefficiencies increased aircraft downtime, delayed engineering decisions, and reduced customer confidence in the investigation process.

The primary objective of this project was to improve the efficiency and effectiveness of compressor component field investigation workflows within a centralized aerospace engineering support environment. Specifically, the study aimed to reduce investigation closure time, improve the completeness and accuracy of initial field data, enhance cross-functional coordination among engineering and customer support organizations, and increase overall investigation visibility for stakeholders. To support this objective, the study applied a structured improvement methodology combining baseline workflow analysis, stakeholder interviews, and an Agile-inspired sprint implementation framework.

LITERATURE REVIEW

Field investigation processes in aerospace engineering

Technical field investigations are structured activities intended to determine the causes of in-service failures or abnormal behavior in aerospace hardware. Industry guidance emphasizes the importance of systematic data collection, evidence preservation, traceability of components, and formal documentation of findings [1]. Typical investigation stages include initial event reporting, hardware inspection, engineering analysis, safety assessment, customer review, and final documentation [2].

Regulatory authorities and airworthiness organizations require that investigations be supported by verifiable technical evidence, including photographs, dimensional measurements, operating conditions, and maintenance history [1]. Studies in aircraft maintenance engineering indicate that incomplete or inconsistent information at the beginning of an investigation frequently results in conservative engineering assumptions, repeated data requests, and extended analysis cycles [2].

Multidisciplinary coordination is consistently identified as a major challenge in aerospace investigations. Structures, materials, aerodynamics, performance, and controls specialists often work in separate organizational units with independent workloads. Without coordinated workflow, technical assessments tend to occur sequentially, increasing overall closure time and reducing responsiveness to customer needs [3].

Engineering workflow optimization and data quality

Multidisciplinary coordination is consistently identified as a major challenge in aerospace investigations. Engineering disciplines often operate within separate organizational structures, which can lead to sequential technical reviews, limited workflow visibility, and increased investigation closure time. Process mapping tools, standardized intake templates, and centralized tracking systems have been shown to improve workflow transparency, reduce rework cycles, and support more efficient engineering coordination [3][4].

Data quality is repeatedly cited as a dominant factor influencing investigation efficiency. Engineering analyses relied on accurate measurements, clear damage descriptions, serial number traceability, and operational context. When these inputs are missing or ambiguous, engineering teams are required to suspend analysis and request additional information, leading to multiple communication cycles and duplicated effort [4].

Standardized intake forms, reporting checklists, and centralized case-tracking systems improve information completeness and investigation transparency while enabling managers to monitor technical progress [3].

Application of Agile methodology in engineering management

Agile methodology originated in software development but had increasingly been adopted in engineering management and process improvement initiatives. Agile frameworks emphasize short planning cycles, incremental delivery, continuous stakeholder involvement, and adaptability to evolving technical requirements [5].

In engineering environments, Agile principles are applied to improve cross-functional coordination, accelerate problem resolution, and prioritize high-impact improvements. The use of structured sprints, task backlogs, and visual workflow boards has been shown to reduce ambiguity regarding responsibilities and to increase accountability among multidisciplinary teams [5].

Recent research suggests that Agile approaches were particularly effective in environments characterized by uncertainty, evolving information, and strong interdependencies between technical disciplines. These characteristics closely matched those observed in aerospace field investigations, making Agile methodology a suitable foundation for the workflow improvement strategy developed in this project [5].

METHODOLOGY

Scope of the analysis

The project focused on compressor component field investigations conducted within a centralized engineering support organization serving both commercial airlines and military operators. The scope included investigations involving high-pressure compressor cases, fan and front-compressor blades, compressor stator assemblies, and variable stator vane actuation mechanisms.

The analysis addressed the complete investigation lifecycle, beginning with the initial event report generated by the operator and concluding with formal case closure and documentation. Design-phase failure analyses and manufacturing development investigations were excluded from the study.

Key stakeholders included customer support engineers, investigation leads, discipline engineering teams (structures, materials, aerodynamics, performance, and controls), quality and safety personnel, program management, and external customers.

Baseline review and data collection

A baseline review was conducted to characterize the current investigation workflow and identify systemic sources of delay. Four completed investigation cases were selected as representative samples based on component type, customer sector, and closure duration. For each case, data regarding component failure description, closure duration, intake data availability, engineering activities, delay drivers, and final root cause determination were evaluated.

In addition to case documentation, structured interviews were conducted with representatives from investigation leadership, engineering, quality and safety, and customer organizations. These interviews were used to validate observed workflow issues, identify coordination challenges, and capture stakeholder perspectives on improvement opportunities.

Process mapping techniques were then applied to construct a current-state workflow model illustrating organizational handoffs, dependencies between engineering disciplines, and repeated data-request cycles.

Agile-based improvement framework

Findings from the baseline review were consolidated into a set of recurring problem categories, including incomplete initial reports, poor measurement quality, sequential technical assessments, late involvement of quality organizations, and limited investigation visibility across stakeholders.

These issues were translated into improvement objectives and organized into an Agile backlog. The improvement effort was structured into two sprints. The first sprint addressed data quality at intake through the development of standardized reporting templates, mandatory checklists, and classification guidelines. The second sprint focused on workflow execution and management through parallel engineering task planning, visual tracking tools, standardized communication practices, and the definition of a future-state investigation workflow.

Sprint planning activities defined deliverables, task ownership, and prioritization based on expected impact on investigation cycle time and engineering efficiency. This incremental approach enabled early validation of solutions against baseline findings and supported continuous stakeholder feedback throughout the improvement process.

RESULTS

Baseline Workflow Performance

Review of four representative compressor component investigations showed closure durations ranging from three to six months, with an average closure time of approximately 4.6 months. The baseline investigation workflow used within the organization is illustrated in Figure 1. The current-state workflow begins with event reporting and case assignment, followed by hardware and data requests, preliminary multidisciplinary technical review, sequential engineering assessments, safety and compliance review, customer coordination, and final report issuance. As shown in Figure 1, engineering activities were typically performed sequentially and frequently required repeated data clarification cycles, contributing to extended investigation timelines and reduced stakeholder visibility.

Analysis of these investigations indicated that delays were primarily driven by process inefficiencies rather than technical complexity alone. Common delay drivers included incomplete data intake, sequential engineering reviews, limited stakeholder availability, and repeated data clarification cycles. Missing dimensional measurements, environmental operating conditions, and maintenance history frequently prevented engineering teams from initiating technical analysis promptly, resulting in extended investigation timelines. Table 1 summarizes the baseline investigation performance characteristics observed across the representative compressor component cases evaluated in this study.

Figure 1
Current-State Compressor Component Field Investigation Workflow

Table 1
Baseline Compressor Investigation Case Performance Summary

Case ID	Component Type	Closure Time (Months)	Primary Data Gaps	Major Delay Drivers	Root Cause Category
FI-CC-2024-01	HPC Case	6.0	Crack dimensions, internal imagery, operating temperature history	Sequential engineering review, supplier coordination delays	Thermal fatigue cracking
FI-FB-2024-02	Fan Blades	3.0	Impact dimensions, environmental conditions, damage imagery	Poor initial reporting quality, missing environmental data	Foreign object damage (bird ingestion)
FI-ST-2025-01	HPC Stators	5.0	Serial traceability, coating thickness data, maintenance history	Maintenance record retrieval delays, modeling turnaround	Environmental erosion
FI-KIN-2025-02	VSV Kinematic System	4.5	Actuator travel data, lubrication history, fault code snapshots	Multi-discipline coordination delays, dimensional measurement gaps	Progressive wear and contamination

Data Quality and Coordination Findings

Incomplete initial reporting and workflow coordination limitations were identified as the primary contributors to investigation delays. Missing dimensional measurements, damaged imagery, operating conditions, and maintenance history frequently prevented engineering teams from initiating technical analysis, resulting in repeated data clarification cycles. In addition, sequential multidisciplinary reviews and manual stakeholder communication reduced investigation visibility and increased dependency between engineering disciplines, further extending investigation timelines.

Sprint Improvement Outcomes and Future-State Workflow

Improvement initiatives developed during the Agile sprints were consolidated into a redesigned investigation workflow, shown in Figure 2. The future-state workflow introduces mandatory intake compliance validation prior to case acceptance, simultaneous multidisciplinary engineering task execution, early quality and safety engagement, and centralized investigation tracking using sprint-based coordination. These improvements reduce sequential dependencies between engineering disciplines, improve communication transparency, and enable earlier identification of regulatory and safety considerations.

Sprint 2 improvement initiatives focused on workflow execution efficiency through parallel engineering task execution, centralized investigation tracking, and structured multidisciplinary coordination reviews. These improvements reduced sequential dependencies between engineering disciplines and improved investigation visibility. The redesigned workflow integrates intake compliance validation, parallel technical assessments, early quality and safety engagement, and centralized monitoring to improve coordination efficiency and support earlier identification of regulatory considerations.

The proposed workflow integrates intake compliance validation, parallel technical assessments, early quality and safety engagement, and centralized investigation monitoring. The redesigned workflow improves coordination efficiency and supports earlier identification of regulatory and safety considerations.

Based on baseline performance trends and stakeholder validation, the proposed workflow is expected to reduce investigation closure duration by approximately 25 to 35%. The improvements also enhance technical consistency, reduce rework cycles, improve resource utilization, and strengthen communication transparency across engineering and customer support organizations.

Conclusion

The proposed future-state workflow provides a practical framework for improving investigation efficiency, reducing closure time, and strengthening communication consistency across engineering, safety, and customer organizations. These improvements are expected to support increased fleet availability, improved maintenance planning, and more effective engineering resource utilization. The study was limited to using representative case samples and pilot-level workflow implementation. Future work should focus on expanding workflow improvements to additional engine modules and integrating digital investigation management and predictive analytics capabilities to further enhance field issue resolution performance.

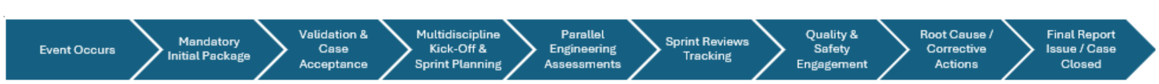

Figure 2

Agile-Based Future-State: Compressor Component Investigation Workflow

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