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Optimizing the Service Bulletin Approval Process in Company X through Lean and Digital Solutions

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Abstract
In the aerospace maintenance sector, timely approval of the Service Bulletins (SBs) is important for guaranteeing aircraft safety, operational continuity, and regulatory compliance (ICAO, 2019). Company X faces persistent delays in its SB approval workflow due to fragmented communication, manual processes, and limited digital integration. This study contributes by being one of the first to combine Lean Six Sigma's DMAIC framework, PDCA cycle and Lewin's change management model in a digitalized SB approval process within a real-world aerospace setting (George, 2003; Moen & Norman, 2010); (Galli, 2018). A pragmatic action research design was adopted across two intervention cycles involving stakeholder feedback, PowerBI analytics and AI-assisted decision support tools. Root cause analysis identified key inefficiencies such as redundant approval loops, unstructured communication, and lack of real-time visibility. Interventions including automated workflows and standardized decision gates significantly reduced SB lead time and improved accountability. The model proved scalable for broader Maintenance, Repair, and Overhaul (MRO) environments facing similar regulatory constraints (Gerger & Firuzan, 2016). This study contributes to both practice and theory by integrating technical process improvement with behavioural change management. It reinforces the strategic role of digital transformation in enhancing compliance and operational resilience in post-pandemic aviation. Future work may explore cross-site implementation and integration with blockchain or predictive analytics for sustained impact (OECD, 2021).
Keywords: Lean Six Sigma, Service Bulletin Optimization, PDCA, Lewin Change Model, Aerospace Maintenance, Change Management

Introduction

In the highly regulated aviation business, Service Bulletins (SBs) are critical for maintaining aircraft airworthiness and ensuring operational safety. However, SB approval processes are frequently characterized by fragmented communication, heavy reliance on manual workflows, and limited digital tools; thus resulting in significant lead-time delays with operational and financial consequences (Gerger & Firuzan, 2016); (Ayeni, Baines, Lightfoot, & Ball, 2011).

Lean Six Sigma (DMAIC) has been successfully applied to aerospace Maintenance, Repair, and Overhaul (MRO), demonstrating improvements in quality and efficiency (Gillingham, 2025). Pairing Lean Six Sigma with digital transformation through AI, IoT, and big data has further enhanced process optimization and waste reduction in industrial contexts (6sigmastudy, 2024).

Organizational change frameworks are essential to implement these technical enhancements effectively. Lewin's Change Management Model (Unfreeze–Change–Refreeze) is commonly used to support frontline workers during digital transitions, especially in aviation (Wren, H., 2024); NBAA, 2020) Additionally, the PDCA cycle underscores the incremental and iterative nature of continuous improvement (Moen & Norman, 2010).

The COVID-19 pandemic further accelerated digital transformation within aviation, driving investment in predictive maintenance, remote operations, and advanced IT systems to enhance resilience (Devara, 2020; MoghadasNian & PourMoradian Esfandabadi, 2024). Having technology shifts underline the need for robust change management to come out new processes effectively.

Based on this backdrop, this study adopts a pragmatic action research which design to optimize the SB approval workflows in Company X. Through the integration of Lean Six Sigma, PDCA and Lewin's Model, having AI-assisted decision systems and automated workflows, this research aim to reduce the overall lead times, enhance various stakeholder accountability and strengthen the regulatory compliance hence creating a scalable solution in the aviation MROs globally.

Literature Review and Proposition Development

Over the years, the maintenance in aerospace industry has experienced a paradigm shift toward operational excellence through using of digitalization, quality frameworks and process improvement methodologies. The SB approval process which concentrate in maintaining aircraft safety and regulatory compliance remains a persistent bottleneck due to its complexity, regulatory burden and stakeholder interdependencies (ICAO, 2019). In order to address all these challenges, many scholars and practitioners have explored through various frameworks which includes the Lean Six Sigma (LSS), the Plan-Do-Check-Act (PDCA) cycle and organizational change models like Lewin's Change Management Model.

Lean Six Sigma and the DMAIC Framework

Lean Six Sigma (LSS) has increased extensive recognition in high-reliability sectors like in aerospace industry for its structured approach in eliminating waste and reducing process variation. Through the core methodology through DMAIC (Define, Measure, Analyse, Improve, Control), it provides a systematic roadmap to identify root causes, implement targeted improvements and institutionalize change (George, 2003). From the research by Gerger and Firuzan (2016) reveals that applying LSS in aerospace maintenance processes can reduce approval cycle time by 30–50%, which improve compliance accuracy and further enhance stakeholder coordination.

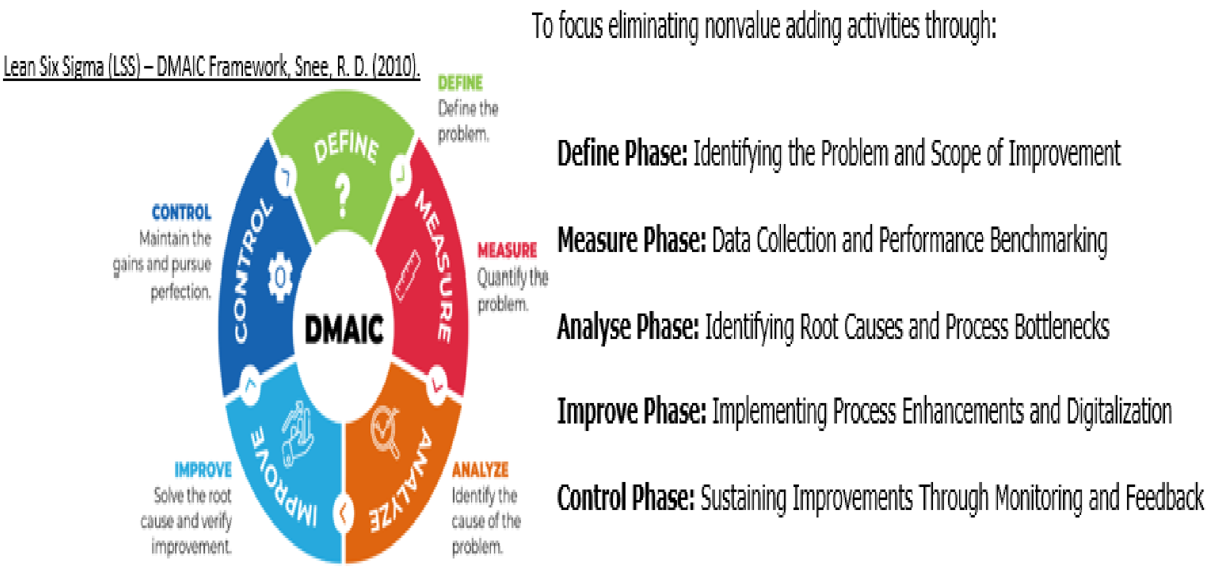

Figure 1: DMAIC Framework

The Define and Measure phases support mapping of current-state workflows and identification of bottlenecks, while the Analyse phase enables root cause analysis using tools such as the Fishbone Diagram and Pareto analysis (Pyzdek & Keller, 2014). The Improve and Control phases focus on piloting interventions such as digital workflows and ensuring sustainability through performance dashboards and audits. As Gillingham (2025) noted, aerospace organizations using LSS have improved turnaround time without compromising on regulatory rigour.

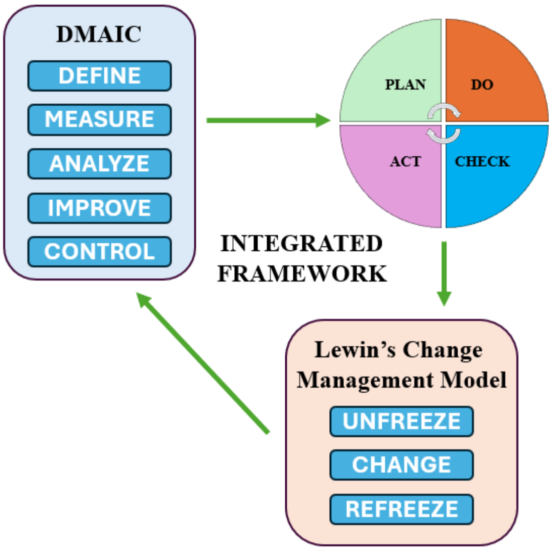

Figure 2: illustrates the integration of Lean Six Sigma's DMAIC process with PDCA's iterative feedback loop and Lewin's Unfreeze–Change–Refreeze model to form a comprehensive approach to optimizing SB approval processes. The framework emphasizes continuous improvement, stakeholder alignment and digital integration

PDCA Cycle and Continuous Improvement

The PDCA (Plan-Do-Check-Act) cycle, popularized by Deming, is widely used in aviation quality control to drive iterative and continuous improvements (Moen & Norman, 2010). In the SB context, The PDCA guide the implementation and enhancement of interventions through structured escalation paths, centralized the digital tracking and automate the decision gates. Several studies have demonstrated that by applying PDCA in aviation maintenance helps to reduces non-value-added activities and supports real-time monitoring of process performance (Taufik, 2020).

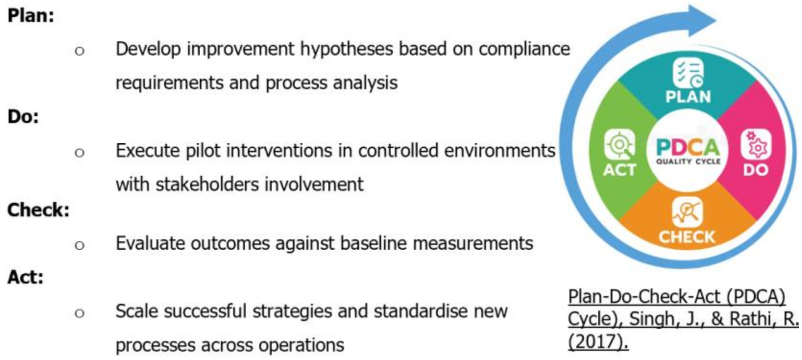

Figure 3 PDCA Cycle

As the strength of PDCA lies in adaptability and enabling the incremental process changes without having large-scale disruptions thus, making it suitable for dealing steady transitions from manual to digital systems (Patel & Deshpande, 2017).

Lewin's Change Management Model

Technological changes in the highly regulated environments like in aviation MRO will require more than process redesign which demand cultural and behavioural alignment. Having Lewin's Change Management Model (Unfreeze–Change–Refreeze) emphasizes preparing the organization for change, implementing new practices and strengthening behaviours to sustain transformation (Galli, 2018). The model has proven effective by reducing resistance and increasing user adoption of digital tools, especially among technical teams resistant to abandoning legacy processes (Kotter, 1995; Wren, 2024).

In the context of SB approval, Lewin's model can be used to ensure stakeholder engagement, clarify roles during escalation and embed new digital routines into organization SOPs. Training programs, feedback loops, and change champions play a pivotal role in sustaining improvement post-intervention.

Digital Transformation in Aerospace MRO

Digitalization is revolutionizing aviation MRO operations. Technologies such as AI-powered decision support systems, cloud-based tracking, and predictive analytics are being adopted to streamline maintenance workflows (OECD, 2021); (MoghadasNian & PourMoradian Esfandabadi, 2024). However, many organizations still rely on fragmented IT systems, unstructured emails, and manual approvals, limiting the potential of these technologies (Ayeni, Baines, Lightfoot, & Ball, 2011). The COVID-19 pandemic further exposed these limitations, prompting a surge in investments in digital maintenance and workflow tools (Devara, 2020).

The integration of data-driven and behavioural approaches enables organizations to improve lead time, accuracy, and compliance concurrently.

Proposition Development

The optimization of the Service Bulletin (SB) approval process in aerospace maintenance requires a multifaceted approach that addresses both technical inefficiencies and organizational behaviours. Drawing upon three established theoretical models: Lean Six Sigma (DMAIC), the Plan-Do-Check-Act (PDCA) cycle, and Lewin's Change Management Model and this study develops three interrelated propositions to guide its action research interventions and assess outcomes.

Theoretical Foundation for Action Research

Lean Six Sigma provides a structured and data-driven methodology to identify inefficiencies and implement improvements using the DMAIC (Define, Measure, Analyse, Improve, Control) framework. In the SB approval context, LSS enables detailed process mapping, root cause identification, and reduction of variation and rework (George, 2003; Gerger & Firuzan, 2016).

The PDCA cycle complements the approach by supporting iterative with incremental improvements. This cycle provides a continuous learning mechanism for evaluating and refining the interventions through cycles of planning, implementation, assessment and adjustment (Moen & Norman, 2010).

However, technical changes alone will be insufficient without addressing human and cultural aspects of change. Through, Lewin's Change Management Model (Unfreeze–Change–Refreeze) could provides a behavioural framework that helps manage the resistance, increase engagement and institutionalise new practices (Galli, 2018); (Kotter, 1995).

These models collectively inform the design, execution, and evaluation of the digital and process-oriented interventions in this research.

Proposition 1: Process Efficiency Improvement through Lean Six Sigma

This proposition is grounded in the DMAIC methodology, which helps define the current state, measure performance, analyse bottlenecks, improve processes through targeted interventions (e.g., automation, decision gates), and control outcomes with standardized monitoring. Performance will be evaluated through lead time reduction, decrease in manual handoffs, and approval cycle consistency.

Proposition 2: Continuous Refinement via PDCA

The PDCA model ensures that interventions are not static. By regularly planning, testing, reviewing, and adjusting, this cycle will allow the organization to address emergent issues and embed a culture of quality improvement. This proposition will be evaluated by tracking frequency of improvements, issue recurrence rates, and stakeholder feedback integration.

Proposition 3: Change Sustainability through Organizational Engagement

This proposition is based on the idea that technological changes succeed only when supported by behavioural alignment. The model's Unfreeze–Change–Refreeze stages will be reflected through pre-intervention engagement, active role alignment during implementation, and post-intervention training and SOP integration. Sustainability will be evaluated through user adoption rates, reduction in resistance incidents, and SOP institutionalization.

Evaluation Framework

To test these propositions, a multi-dimensional evaluation framework is proposed:

Evaluation Area	Related Proposition	Key Indicators	Data Source
Process Lead Time	Proposition 1	SB approval duration, no. of manual steps, rework frequency	PowerBI reports; workflow logs
Iterative Improvement	Proposition 2	No. of PDCA cycles completed, improvements made, issue recurrence	FGD summaries; change logs
Organizational Readiness	Proposition 3	Stakeholder engagement levels, feedback scores, adoption rate	Surveys; interviews; SOP compliance logs
Regulatory Compliance Accuracy	Proposition 1 & 3	Audit scores, documentation error rates	QA audits; internal review reports

Together, these three propositions offer a holistic and theoretically grounded roadmap for optimizing the SB approval process. They integrate operational efficiency, continuous learning, and organizational change thus making the intervention both effective and sustainable. Through the insights generated by these propositions will contribute to both academic literature and practical improvements for the MRO aerospace industry.

Methodology

Research Design: Action Research Framework

This study adopts a pragmatic Action Research (AR) methodology, which is particularly suitable in addressing real-world organizational problems through the collaborative inquiry and iterative change (Coghlan & Brannick, 2014). Action Research is ideal for process improvement in the complex environments like aerospace MRO industry, as it allows both practical interventions and reflective learning (Chevalier & Buckles, 2019).

The AR approach is implemented through the following two cycles:

- **Cycle 1 (Feb 25 – Jul 25):** During this period. The cycle focus on the process mapping, root cause analysis and piloting of basic digital tools and automated approval flows.
- **Cycle 2 (Aug 25 – Nov 25):** Where emphasise the process refinement, integration of stakeholder feedbacks, implementing of AI-assisted decision tools through the Robotics Process Automation (RPO) and the standardization through updated SOPs.

The structure of this study aligns with the PDCA cycle proposed by Kemmis, McTaggart, and Nixon (2014), which ensuring that every intervention is meticulously planned, tested and evaluated.

Organizational Context and Participants

The research was conducted at Company X, a global leader in aircraft propulsion. Participants included process owners, quality assurance staff, digital system engineers, and program managers involved in the SB approval process.

A purposive sampling method was used to select 15 key stakeholders for interviews and workshops based on their involvement and decision-making authority in the SB process.

Data Collection Methods

Multiple qualitative and quantitative data collection tools were employed:

- **Document Analysis:** Review of SB workflows, approval SOPs, and historical approval records.
- **Interviews and Focus Group Discussions (FGDs):** Gathered insights into bottlenecks, communication gaps, and change resistance.
- **PowerBI Dashboards:** The dashboards, built on Power BI Desktop with cloud integration via Power BI Service, enabled dynamic data visualization and stakeholder access across departments.
- **Observation Logs:** Tracked user behaviour and system interactions post-intervention.

Document analysis, interviews, and focus group discussions (FGDs) began in February 2025. Subsequently, the PowerBI testing phase commenced in mid-June 2025, allowing selected stakeholders to assess the system's reliability and functionality prior to full implementation by August 2025.

Year/month depart. date from S/C	202411		202412		202501		Total	
Excusable Type	Days Impacted average	Number of PO	Days Impacted average	Number of PO	Days Impacted average	Number of PO	Days Impacted average	Number of PO
DICA Application	29920.55	69	16.95	80	19.26	65	9659.47	214
TC	1.49	72	1.71	95	1.07	46	1.49	213
SURGE INPUT	4.51	74	5.48	89	6.00	35	5.21	198
PO MISSING	14.28	29	15.23	31	75.83	29	34.66	89
S/E	16.55	11	13.00	22	4.37	30	9.51	63
DOC	24.62	13	7.55	11	5.15	20	11.50	44
PO CLARIFICATION	15.25	16	31.67	6	9.90	10	16.66	32
WARRANTY					8.26	23	8.26	23
LATE PAYMENT	18.00	11	8.20	5			14.94	16

Figure 4 PowerBI dashboard

AI Tool: For AI-enabled analysis, Robotic Process Automation (RPA) was deployed to extract and categorize SB approval records from multiple systems, while machine learning classifiers were piloted to predict high-risk SBs likely to exceed approval deadlines based on historical patterns.

Robotic Process Automation (RPA) is scheduled to begin integration trials with the SAP system in October 2025 to address existing integration gaps. This mixed-methods approach enables a comprehensive diagnosis and evaluation of the implemented process changes.

Measures

The following KPIs were measured pre- and post-intervention:

- Average SB approval lead time (days)
- Number of approval loops

- Frequency of email clarification cycles
- Stakeholder satisfaction score (survey-based)
- Clarification closure rate

Data Analysis

Data were analysed using a combination of qualitative and quantitative techniques:

- Thematic Analysis (Braun & Clarke, 2021) was used to extract key themes from interviews and FGDs related to resistance, accountability, and communication.
- Process Performance Metrics were derived from PowerBI reports to measure pre- and post-intervention impact on lead time, approval cycle time, and frequency of errors.
- Root Cause Analysis tools such as the Fishbone Diagram and 5 Whys/1How were applied during Cycle 1 to identify sources of inefficiencies.

Comparative analysis was used to assess intervention outcomes across the two action cycles.

Discussion

The implementation of Lean Six Sigma principles, coupled with PDCA and Lewin's Model, yielded marked improvements. Approval lead times decreased from an average of 31.67 days to under 10 days. The AI-driven decision support tool streamlined categorization of SBs, and standardized workflows reduced clarification loops. Resistance was addressed via training and stakeholder engagement. The results validate that structured digital interventions can reshape legacy workflows, but also highlight the need for organizational readiness and leadership alignment.

Recommendations and Research Limitations

The findings from this study support several actionable recommendations to enhance the sustainability and impact of SB approval process improvements. First, organizations should institutionalize process ownership by assigning dedicated roles responsible for monitoring SB timelines, ensuring accountability, and initiating timely escalations. Second, implementing a scalable digital workflow system where featuring AI-assisted decision support and real-time tracking dashboards that is recommended to streamline communication and reduce lead times. Third, by embedding a culture of continuous improvement through systematic PDCA review cycles, integrating frontline feedback and adapting to monitoring updates will be the key for sustaining gains. Furthermore, Having structured training programs and frequently updates of the SOPs are require to reinforce the new digital practices and ensuring regulatory compliance. Lastly, the optimized framework should extended beyond SB approvals and to other compliance-driven processes, for instance through the engineering change requests and maintenance documentation, this is to amplify the benefits of digital standardization and alignment of cross-functional.

Despite its practical relevance, this research faced several limitations which also highlight for future research opportunities. This study was limited to a single-case context within Company X, which may limit of the generalizability of findings to other aviation MRO company with different operational cultures or maturity levels. To mitigate this, future studies could look into multi-site comparisons across global aviation MRO providers to test the framework's adaptability and robustness under diverse settings. Also, the research observation period was limited to short-term outcomes. As such, longitudinal studies are recommended to assess the sustainability of improvements in compliance, accountability and behaviour change over time.

Additionally, this study has successfully integrated RPA and PowerBI, it did not leverage emerging technologies such as blockchain or ERP level automation. Future research could further explore the integration of these technologies to provide better immutable and transparent audit trails for SB approval workflows, whereby enhancing traceability and compliance assurance. Having of the stakeholder input was also primarily sourced from those directly involved in the intervention, potentially introducing bias. By growing future data collection to include independent evaluators and expansion of the stakeholder groups can further improve objectivity and external validity. Conclusively, this study was conducted within a single regulatory jurisdiction. To further extend its applicability, future research should assess the model's effectiveness across various different civil aviation authorities and regulatory environments, paving the way for globally harmonized digital SB approval systems.

Having to address these limitations with targeted follow-up research, future studies can build on the current framework and contribute to wider innovation through digital transformation, compliance assurance and operational excellence within the aerospace MRO ecosystem.

Conclusion

This study offers significant contributions to both practice and academic knowledge by presenting a comprehensive and integrative model to optimize the SB approval process within Company X. The integration of Lean Six Sigma's DMAIC framework, the PDCA cycle and Lewin's Change Management Model validates the effectiveness of combining technical efficiency strategies with structured behavioural change interventions. Practically, this research presents actionable strategies that reduce the overall approval lead time, enhance regulatory compliance and strengthen cross-functional collaboration; these areas that are important in the highly regulated aerospace maintenance environment (ICAO, 2019; Taufik, 2020).

Theoretically, this study addresses a gap in the literature where prior research has mainly focused on automation and technical process mapping while understating the human and organizational dimensions of change (Crespo Márquez, 2022; Galli, 2018). By integrating Lewin's Change Model into a Lean framework, this research brings out the importance of cultural readiness, resistance mitigation and employee engagement in sustaining long term operational improvements. This interdisciplinary approach not only adds depth to current process optimization models but also enriches the body of knowledge on organizational change in technical and compliance-driven industries (Kotter, 1995; Pacolli, Bajtijarevic, & Hamidi, 2022).

Beyond Company X, this proposed model establishes strong scalability potential. MRO providers across the commercial aviation industry face similar challenges, including fragmented workflows, regulatory pressure, and aging digital infrastructure. As noted by Gerger and Firuzan (2016), standardizing and digitizing MRO processes can lead to up to 50% reductions in lead time. Thus, the modular nature of this model where core components like AI-supported decision trees, automated tracking systems, and PDCA-guided continuous improvement cycles that makes it adaptable across varied operational settings and organizational cultures. This flexibility aligns with ICAO's call for global harmonization of maintenance practices through digitalization and quality frameworks (ICAO, 2019).

Looking forward, future research could examine the full-scale implementation of this model across Company X's multinational operations, evaluating how varying regulatory jurisdictions and cultural environments affect adoption and effectiveness. Expanding the model to include blockchain technologies could offer secure, transparent, and immutable approval traceability, while machine learning algorithms could enhance predictive capability in maintenance decision-making (OECD, 2021; Reddy, 2024). Additionally, longitudinal studies could provide deeper insights into the long-term impact of these interventions on workforce productivity, compliance sustainability, and customer satisfaction in MRO environments.

Overall, this research makes a meaningful contribution through theory and practice. From the theoretical perspective, it brings together process improvement tools like Lean Six Sigma and PDCA with Lewin's Change Management Model to show how technical upgrades and people-focused strategies can work hand-in-hand. This actually combined approach fills a gap in existing research, which is often overlooked by the human side of digital transformation. In practice, the study provides real-world insights for aviation MRO organizations like Company X which faces complex regulations and outdated systems. The successful implementation of AI tools, automated approvals and continuous improvement cycles clearly shows how such a model can reduce delays, improve compliance, and build a stronger teamwork. Most importantly, through this model isn't just useful for Company X; it can be adapted and applied by other companies in the aviation industry who are looking to modernize their processes and stay competitive in a fast-changing world.

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