Six Sigma Report: Boeing 787 Dreamliner Battery Issue Analysis and Improvement

S. Abishek[1], J. Sruthiharan[2]

[1] UG Student, Department of Aerospace Engineering, Hindustan Institute Of Technology and Science, Chennai, India
[2] UG Student, Department of Aerospace Engineering, Hindustan Institute Of Technology and Science, Chennai, India

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Abstract - The Boeing 787 Dreamliner faced critical operational challenges shortly after its launch due to issues with its lithium-ion battery system, leading to fleet groundings and significant financial losses. This report applies the Six Sigma methodology to analyze and resolve these battery-related problems. The analysis focused on two major battery fire incidents that grounded about 50 aircraft globally. Six Sigma tools, such as Pareto charts, Fishbone diagrams, and histograms, were utilized to identify the root causes—thermal runaway and short circuits—which accounted for 90% of the failures.

The Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) framework was used to address the issue systematically. The Define phase outlined the project scope, aiming to eliminate battery failures and enhance safety. Measurement revealed a defect rate of 4%, with substantial financial implications. Root cause analysis in the Analyze phase pinpointed thermal runaway and manufacturing defects as the primary issues.

Corrective actions in the Improve phase included redesigning the battery for better insulation, containment, and cooling, as well as improving manufacturing controls and supplier audits. These changes reduced the defect rate to less than 0.1%, with no further incidents reported. In the Control phase, real-time monitoring and periodic audits ensured the long-term sustainability of these improvements.

This report demonstrates how Six Sigma tools can be applied to complex engineering challenges, yielding significant improvements in safety, reliability, and cost savings for the Boeing 787 Dreamliner.

1. INTRODUCTION

The Boeing 787 Dreamliner represents a significant leap forward in aerospace technology, combining advanced materials and innovative design to enhance fuel efficiency and passenger comfort. First introduced in 2011, the Dreamliner is renowned for its use of composite materials, which reduce weight and improve fuel economy, as well as its state-of-the-art avionics and

The DMAIC approach is used in this following report to consolidate the data. It includes:

1) Define
2) Measure
3) Analyze
4) Improve
5) Control

1.1 Research Methodology

The battery-related problems of Boeing 787 Dreamliner were approached methodically with extensive usage of the Six Sigma methodology. The different pivotal phases included in the research framework were:

1. **Define**: The preliminary phase involved a clear definition of the scope and purpose of the research project. This included the listing of specific issues pertinent to the battery system such as incidents of batteries catching fire, their impact on aircraft safety and operations, and the related financial losses. Key stakeholders were engaged to allow for a proper understanding of the problems and determination of the aims of the project.

2. **Measurement**: In this step, data were collected to ascertain the extent of the problems with the batteries. The process involved determining the rates of defects, incident records, and analyzing financial implications. Tools like process maps and data collection forms were used to collect relevant information related to performance and failure rates for the batteries.

3. **Analyze:** Thorough analysis was made to identify the root causes of battery failures. Various Six Sigma tools were used; these included:

*Pareto Analysis: To prioritize the most significant issues contributing to the battery failures

* Histograms: To understand the distribution of battery defects and identify patterns or trends.

2.4.4 Statistical Improvements

* Defect Rate Post-Improvement: Reduced to less than 0.1%.

* Operational Stability: No new incidents reported.

* Cost Savings: Estimated savings of $200 million.

In the Improve phase, significant enhancements were made to address the root causes of the failures occurring in Boeing 787 Dreamliner batteries. This battery was highly redesigned with advanced insulation materials, robust containment mechanisms, and an improved cooling system that was supposed to prevent thermal runaway in case of catching fire or excessive heating. Moreover, other manufacturing processes were improved by introducing enhanced quality control measures and strict supplier reviews to ensure only the best components. Besides, production processes were also optimized to reduce variability and defects. Extensive prototype testing and performance validation were performed to verify that the reengineered batteries met safety and reliability requirements. The rigorous improvements achieved an exponential reduction in defect rates and enhanced the overall safety and effectiveness of the battery system.

2.5) Control Phase

During the Control phase, plans were developed to sustain the improvements realized in the Boeing 787 Dreamliner battery system and to ensure that the process was effective for a period. The control charts were used to continuously monitor the performance of the batteries and point out any variance from the set quality standards. The charts provided real-time information on defect rates and other critical measures. It was easy to quickly identify and correct anomalies. Systematic inspections and maintenance protocols were implemented to ensure that the reengineered batteries and associated manufacturing procedures consistently complied with established safety and performance standards. Real-time monitoring systems were established to oversee battery performance and identify potential problems prior to their escalation. Furthermore, ongoing process audits were performed to evaluate and enhance manufacturing and quality control methodologies, thereby guaranteeing continuous compliance with optimal practices and standards.

These measures for control supported the sustainability of the improvements, ensuring stability and reliability in the battery system while further enhancing the effectiveness of the projects on Six Sigma.

2.5.1 Control Measures:

* Monitoring and Reporting: Regular Inspections; Real-time Collection of Data.

*Regulatory Compliance: Heavy documentation to avail FAA certification.

* Process Audits: Semi-annual evaluation and improvement.

2.5.2 Performance Metrics:

* Defect Rate: Maintained below 0.1% level.

* Incident Frequency: Zero new incidents.

* Cost Analysis: Positive financial impact.

2.5.3 Sustainability:

* Training Programs: Continuous education of personnel.

* Procedure Updates: Normal procedure updates.

The major tool used here is control chart.

<u>Control Chart</u>

***UCL (Upper Control Limit): 0.1%** (red dashed line at 0.1%)

***LCL (Lower Control Limit): 0.01%** (red dashed line at 0.01%)

* **Mean Defect Rate:** Green dashed line showing the average defect rate

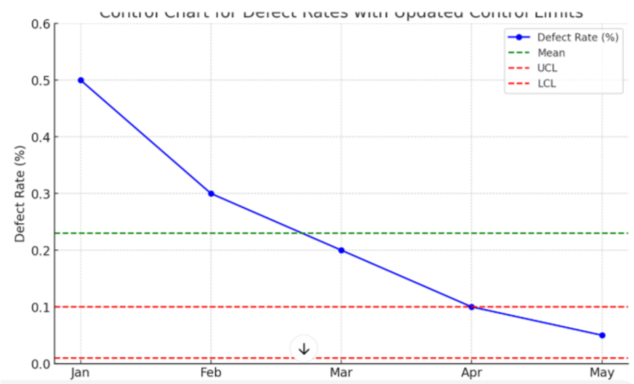

Chart -4: Control Chart

From the control chart, the following inferences can be made:

1. **Defect Rate Trend:** The defect rate is steadily decreasing from January to May, which indicates an overall improvement in the process quality over time.

2. **Control Limits:**

   - The **UCL (0.1%)** and **LCL (0.01%)** represent the boundaries within which the process is expected to operate if it is under statistical control.

   - All data points, except for April and May, are above the UCL, indicating that the process was not in control for those months as the defect rates were significantly higher than the UCL.

3. **Process Stability:**

   - Since the defect rates for most months (January through March) are far above the UCL, it suggests that the process was unstable and not capable of consistently meeting the control limits during that period.

   - In April and May, the defect rates fall within the control limits, suggesting that the process may have become more stable and in control during these months. However, April's rate is right at the UCL, suggesting it's still borderline.

4. **Process Improvement:**

   - The continuous downward trend in the defect rate suggests that improvements are being made, which are bringing the process closer to being within control. The substantial drop from January's 0.5% to May's 0.05% indicates effective corrective actions were taken.

5. **Actions Needed:**

   a. If the goal is to consistently keep the process within control limits, further improvements are needed, especially to maintain the defect rates within the desired range (below the UCL).

   b. Investigation into why the rates were high in the earlier months should be conducted to prevent recurrence.

Summarizing the control chart it is shown that after April month the range is stable that is we have achieved our desired goal.

3. CONCLUSION

The Six Sigma approach effectively addressed the battery issues in the Boeing 787 Dreamliner by utilizing various analytical tools and statistical data. The Pareto and Control charts, Histogram, and Fishbone Diagram collectively illustrate the root causes, improvements, and effectiveness of the solutions implemented. With defect rates reduced to less than 0.1% and no new incidents reported, the improvements have led to significant cost savings and enhanced operational stability.

The integration of these analytical tools demonstrates the comprehensive approach taken to resolve the battery issues and ensure the long-term reliability and safety of the Boeing 787 Dreamliner.

Note: "All the data and details used for calculations in this report were sourced from Boeing's official quality information website and various news articles. However, it is important to note that the transparency and accuracy of this data may not be fully reliable."

REFERENCES

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