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# Reducing Resolution Time for Key Malfunction Defects Using Six Sigma DMAIC Methodology

**Prajyot Kavitake, Ganesh Gujjeti, Nachiket Pusadkar, Rahul Megharaj and Sepideh Abolghasem**
Engineering Management, Manufacturing Systems Engineering and Management
California State University, Northridge
Northridge, CA, USA
prajyot.kavitake.685@my.csun.edu, ganesh-baburao.gujjeti.210@my.csun.edu
nachiket-pravin.pusadkar.458@my.csun.edu
rahul.megharaj.682@my.csun.edu, sepideh.abolghasem@csun.edu

## Abstract

This Six Sigma DMAIC project addresses delays in resolving key malfunction defects in Kensington wireless handheld keyboards. The current resolution time averages 15.5 days, exceeding the target of 12.5 days and leading to a 20% drop in customer satisfaction. The DMAIC framework was utilized to identify and address key root causes, including outdated communication methods and insufficient employee training. To resolve these issues, the project implemented a modern communication platform to streamline interdepartmental coordination and introduced comprehensive training programs to enhance employee skills and efficiency. These targeted interventions resulted in a substantial reduction in resolution time, improved process stability, and increased customer satisfaction. By focusing on communication and training, the project highlights the significant impact of operational improvements on organizational performance. The findings demonstrate the effectiveness of Lean Six Sigma principles in delivering measurable business outcomes and emphasize the value of data-driven strategies for achieving long-term operational excellence.

## Keywords
DMAIC, Lean Six Sigma, Employee Training, Communication Improvement, Process Improvement

## 1. Introduction
In today's competitive marketplace, customer satisfaction plays a vital role in sustaining business success. For Kensington, a manufacturer of wireless handheld keyboards, delays in resolving key malfunction defects have significantly impacted customer satisfaction, resulting in a 20% decline. The average resolution time of 15.5 days exceeds the acceptable target of 12.5 days, highlighting inefficiencies in the current resolution process. These delays not only affect customer loyalty but also hinder the company's operational performance. To address these challenges, this study employs the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) methodology, a structured framework for process improvement. Root cause analysis identified outdated communication methods and insufficient employee training as critical issues contributing to the delays. By implementing targeted solutions, including a modern communication platform to streamline coordination and comprehensive training programs to improve workforce competency, the project aims to reduce resolution time, enhance process efficiency, and improve customer satisfaction. This paper demonstrates how Lean Six Sigma principles can drive meaningful change through data-driven strategies. The results underscore the importance of addressing specific pain points in the resolution process to achieve measurable improvements in both operational efficiency and customer outcomes. Through this case study, the paper

provides actionable insights for organizations facing similar challenges, emphasizing the role of continuous improvement in maintaining competitive advantage.

### 1.1 Objectives

This study aims to implement a structured Six Sigma DMAIC methodology to reduce the resolution time for key malfunction defects in Kensington wireless handheld keyboards and improve customer satisfaction. It focuses on addressing inefficiencies in communication and employee training, which are critical contributors to the delays. By adopting a modern communication platform, interdepartmental coordination can be streamlined, minimizing bottlenecks in the resolution process. Additionally, comprehensive training programs are designed to enhance employee skills, ensuring quicker and more effective defect handling. The proposed improvements aim to stabilize the resolution process, achieve the target resolution time of 12.5 days, and recover the 20% decline in customer satisfaction. These results are expected to support sustainable operational improvements and provide actionable insights for long-term business success.

## 2. Literature Review

The Six Sigma DMAIC methodology has been widely recognized as a powerful tool for process improvement across diverse industries. This methodology provides a structured framework for identifying, analyzing, and resolving inefficiencies to enhance organizational performance. Over the years, multiple studies have explored the application of Six Sigma in manufacturing, service sectors, and specialized fields like healthcare and energy, focusing on tools, challenges, and outcomes. This review categorizes existing literature based on common themes such as applications, tools, critical success factors, and barriers to Six Sigma implementation.

Numerous studies have demonstrated the versatility of Six Sigma DMAIC across industries. For example, Kumar et al. (2008) applied DMAIC to enhance customer service in the U.S. electronics retail sector, creating service blueprints and conducting SERVQUAL surveys to improve customer satisfaction. Similarly, Kaushik and Khanduja (2008) implemented Six Sigma in a thermal power plant, achieving significant energy savings by reducing water consumption. Healthcare applications were explored by Taner et al. (2007), who showed how Six Sigma improved resource utilization, reduced bottlenecks, and enhanced working conditions, thereby increasing market share for healthcare organizations.

The methodology incorporates a range of tools, as highlighted by Tjahjono et al. (2010), who categorized Six Sigma into statistical tools, business culture, and operational philosophy. Techniques such as control charts, process capability analysis, and DOE were integral to studies like Li et al. (2008), which improved solder paste printing by reducing variation in process thickness. Kumar et al. (2007) utilized Pareto analysis and regression to address casting defects, achieving significant cost savings and increased process capability.The implementation of Six Sigma is not without challenges. Mohamed's study highlighted soft barriers such as knowledge gaps and lack of support, as well as hard barriers like funding and resource constraints in developing countries. Firka (2010) emphasized that Six Sigma is not a one-size-fits-all solution, and its adaptation must consider organizational culture and resource availability. In small enterprises, Sinthavalai (2006) proposed web-based training systems to overcome high consultancy costs and ensure employee engagement.

In summary, Six Sigma DMAIC is a flexible and effective methodology for improving processes, as evidenced by its applications across diverse sectors. The methodology's success is rooted in its robust tools, adaptability, and focus on measurable outcomes. However, challenges such as resource constraints and organizational resistance highlight the need for tailored strategies and innovative solutions to maximize its impact. Future research should focus on integrating modern technologies like AI and IoT with Six Sigma to address emerging industrial complexities.

## 3. DMAIC Methodology

The Six Sigma DMAIC methodology was employed to address prolonged defect resolution times in Kensington wireless handheld keyboards. Recognized as a robust business management tool, it focuses on improving operational efficiency and reducing process inefficiencies. Primary data was gathered through discussions with quality assurance personnel, while secondary data was obtained from internal databases. Expert insights and literature reviews supported the study’s approach. The Define phase clarified the problem of resolution delays, and the Measure phase established baseline performance metrics. Root cause analysis in the Analyze phase identified key issues such as outdated communication methods and inadequate training. In the Improve phase, solutions like a modern communication platform and comprehensive training programs were implemented. The Control phase introduced monitoring mechanisms to sustain improvements. This structured methodology resulted in reduced resolution times, improved customer satisfaction, and enhanced process stability, showcasing the effectiveness of Six Sigma DMAIC.

## 4. Case Study

A The defect resolution process for Kensington wireless handheld keyboards faced significant challenges, with an average resolution time of 15.5 days exceeding the target of 12.5 days. This delay not only resulted in financial implications due to increased operational costs but also led to a 20% decline in customer satisfaction. Recognizing the urgency of addressing this issue, the quality assurance team proposed using the Six Sigma DMAIC methodology to streamline the resolution process and meet the target timeline. The Six Sigma project was approved by senior management and assigned to a cross-functional improvement team comprising trained Six Sigma practitioners. The team systematically followed the DMAIC framework: Define: Clearly identify the problem and establish project goals. Measure: Assess the current resolution process and establish baseline performance metrics. Analyze: Identify root causes of delays and determine areas requiring intervention. Improve: Implement targeted solutions, including improved communication platforms and comprehensive training programs. Control: Develop mechanisms to ensure sustained process improvements and achieve long-term efficiency.

### 4.1 Define

The define phase focuses on identifying the prolonged defect resolution time of 15.5 days for Kensington wireless handheld keyboards, which exceeds the target of 12.5 days and has resulted in a 20% decline in customer satisfaction. The project charter outlines the problem, business case, and project goals, aiming to reduce resolution times within three months to improve customer satisfaction. To understand the current state, a SIPOC diagram was created, mapping key elements such as suppliers (customers, helpdesk, technical team, IT systems), inputs (defect reports, case details, technical data), processes (logging, diagnosing, and resolving defects), outputs (resolved defects and improved satisfaction), and customers (end users).

Table 1. Project Charter

**Project Charter**

| Problem Statement | Business Case & Benefits |
|---|---|
| The current customer complaint that the average resolution time for the key malfunction defect takes an average of 15 ½ days, significantly exceeding the target resolution time of 12 ½ days. This delay has led to increased customer dissatisfaction, with a 20% decrease in customer ratings. | Improving the defect resolution time from 15 ½ days to 12 ½ days will reduce support costs, increase revenue through better customer retention, and lower operational expenses by streamlining processes. These changes will drive a 20% improvement in customer satisfaction, leading to higher CSAT scores and loyalty, while also strengthening the company's improved reputation for reliability and service, positioning it for long-term growth and competitive advantage. |

**Goal Statement**

Reduce the average defect resolution time from 15 ½ days to 12 ½ days within 3 months.This will result in a 20% improvement in customer satisfaction ratings and retention.

**Timeline**

| Phase | Planned Completion Date | Actual |
|---|---|---|
| Define: | September 25th | October 2nd |
| Measure: | October 9th | November 6th |
| Analyze: | November 1st | November 6th |
| Improve: | November 10th | December 4th |
| Control: | November 18th | December 4th |

**Indicator**

Average Resolution Time (in days)

Average CSAT score (in range 1 to 5)

**Project Scope**

**Inscope:** Analysis of key malfunctions in the customer support process, improvement of response time, and enhancement of resolution efficiency. Focus will be on the entire defect resolution lifecycle, from defect reporting to final resolution and improving the customer ratings.

**Outscope:** Defects unrelated to key malfunctions, as well as external factors that may affect customer satisfaction beyond defect resolution like product performance issues not related to the key malfunction.

**Team Members**

| Position | Person | Title | % of Time |
|---|---|---|---|
| Team Lead | Prajyot Kavitake | | 25% |
| Team Member | Nachiket Pusadkar | | 25% |
| Team Member | Ganesh Gujjeti | | 25% |
| Team Member | Rahul Megharaj | | 25% |

| Suppliers (S) | Inputs (I) | Process (P) | Outputs (O) | Customer (C) |
|---|---|---|---|---|
| Customer | Defect reports from customer | Customer reports defect through support channels | Resolved defect and feedback | Customer |
| Helpdesk Team | Case details from helpdesk systems | Helpdesk logs and escalates defect | Improved customer satisfaction | |
| Technical Team | Diagnostic tools and technical data | Technical team investigates defect | Reduced average resolution time | |
| IT Systems (for tracking issues) | Resource allocation (support and technical staff) | Resolution steps identified and executed | Data for performance tracking | |
| | Process documentation for defect handling | Defect fixed and customer informed | | |

Additionally, a process flowchart was developed to visualize the current workflow and pinpoint inefficiencies for targeted improvement. These tools provide a comprehensive understanding of the problem and establish a clear direction for the subsequent phases.

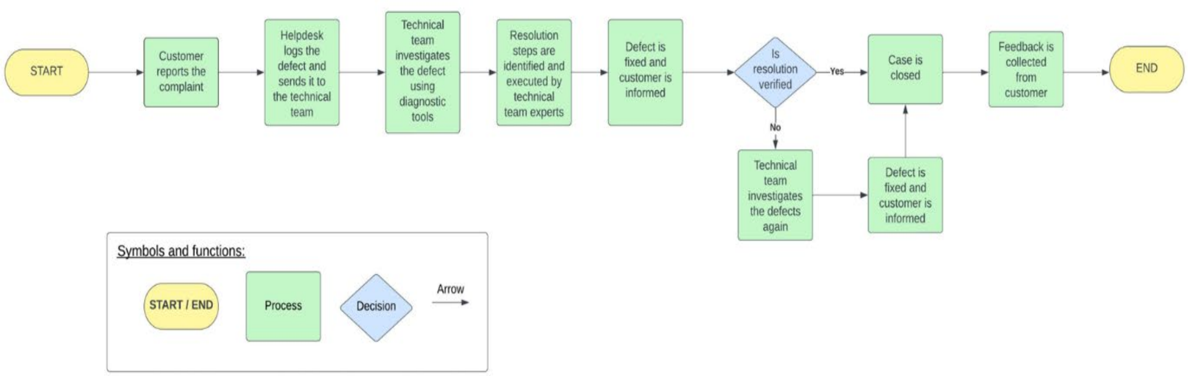


Figure 1. SIPOC with Process Map

## 4.2 Measure

In the measure phase, comprehensive data on defect resolution times and customer satisfaction was collected to establish baseline metrics and assess process performance. The dataset includes key inputs such as defect types, severity levels, and defect reporting dates, with outputs captured as resolution times (in days), customer ratings, and resolution statuses.

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | Product_ID | Defect_Type | Severity_Level | Defect_Reported_Date | Resolved | Resolution_Time_Days | Customer_Rating |
| 2 | 4 | Key Malfunction | High | 2023-01-01 | Yes | 12 | 4 |
| 3 | 26 | Key Malfunction | High | 2023-01-10 | Yes | 14 | 4 |
| 4 | 42 | Key Malfunction | High | 2023-01-15 | Yes | 29 | 2 |
| 5 | 47 | Key Malfunction | High | 2023-01-16 | Yes | 26 | 2 |
| 6 | 58 | Key Malfunction | High | 2023-01-20 | Yes | 5 | 5 |
| 7 | 79 | Key Malfunction | High | 2023-01-27 | Yes | 21 | 3 |
| 8 | 136 | Key Malfunction | High | 2023-02-13 | Yes | 6 | 5 |
| 9 | 140 | Key Malfunction | High | 2023-02-14 | Yes | 1 | 5 |
| 10 | 149 | Key Malfunction | High | 2023-02-19 | Yes | 2 | 5 |

Figure 2**.** Sample Data (How the Data Looks)

The analysis of defect resolution data revealed significant performance gaps. The mean resolution time was 15.48 days, exceeding the target of 12.5 days, with a median of 15 days. A standard deviation of 9.17 days highlighted high variability, with 75% of cases resolved within 25 days, but 15.85% exceeding 27 days. Process capability analysis showed a Cp of 0.451, indicating high variation, and a Cpk of 0.433, reflecting poor process centering. Furthermore, 21.95% of cases fell outside specification limits, emphasizing the need for improvement. Data for the analysis was collected from historical defect records and customer feedback surveys, covering a one-year period. Statistical tools such as Excel and JMP were used to perform the analysis and establish baseline metrics. These findings underscore the critical need for targeted interventions to enhance process efficiency and reduce variability.

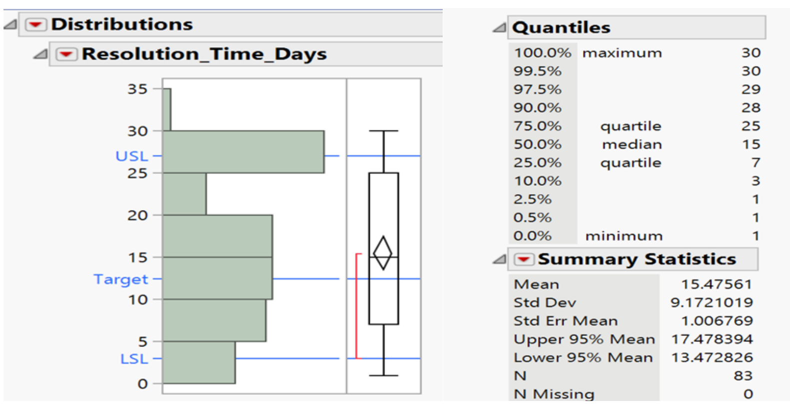


Figure 3. Descriptive Statistics on JMP

The data highlights significant delays in defect resolution and process variability, necessitating targeted improvements to align with the target resolution time of 12.5 days. High variability and poor process centering emphasize the need for process stabilization and better control mechanisms.

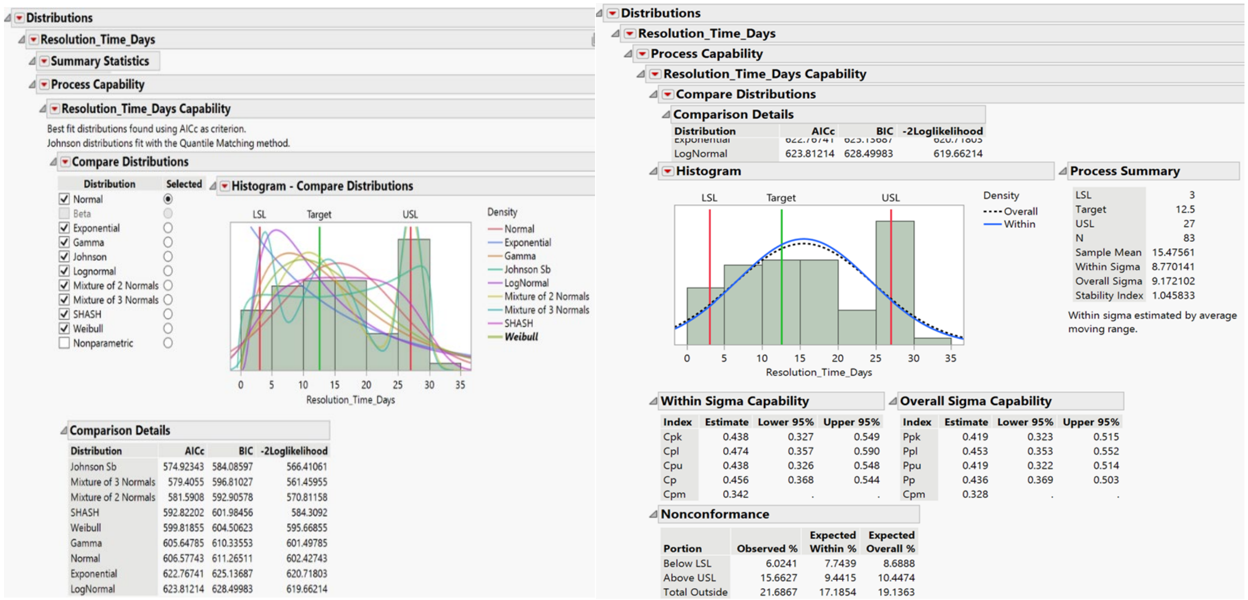


Figure 4. Process Capability on JMP

## 4.3 Analyze

The Analyze Phase revealed key root causes of delays in defect resolution, including insufficient training, ineffective inventory management, outdated communication methods, lack of standardized workflows, and outdated tracking systems. These issues were identified using tools like the Five Whys, Fishbone Diagram, and a detailed process map.

Table 2. 5 Why's

| Problem | Why 1 | Why 2 | Why 3 | Why 4 | Why 5 | Root Cause |
|---|---|---|---|---|---|---|
| Lack of Training | Personnel lack skills to resolve issues. | Insufficient training. | Training programs not prioritized in the budget. | Budget focuses on immediate operational needs. | Management focuses on short-term results. | Lack of investment in training programs due to a short-term focus by management. |
| Spare Part Availability | Spare parts are not always available. | Ineffective inventory management. | No automated system for tracking/reordering. | No investment in modern inventory technology. | Management perceives it as a non-essential expense. | Lack of investment in automated inventory management due to budget constraints. |
| Delayed Communication Among Departments | Communication between departments is slow. | Outdated communication methods. | No streamlined communication platform. | Lack of awareness of platform benefits. | No process improvement assessments conducted. | Lack of process improvement assessments to identify and implement modern tools. |
| Frequent Handoffs | Too many handoffs in the resolution process. | Tasks divided without a clear owner. | Responsibilities not well-defined. | No standardized workflow for resolution. | No formal process guidelines established. | Absence of standardized workflow due to lack of formal process guidelines. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Outdated Tracking Systems | Tracking system is outdated. | No system upgrades. | Current system considered good enough. | Limited awareness of modern system benefits. | No focus on continuous process improveme nt. | Lack of focus on continuous improvement, leading to outdated tracking systems. |

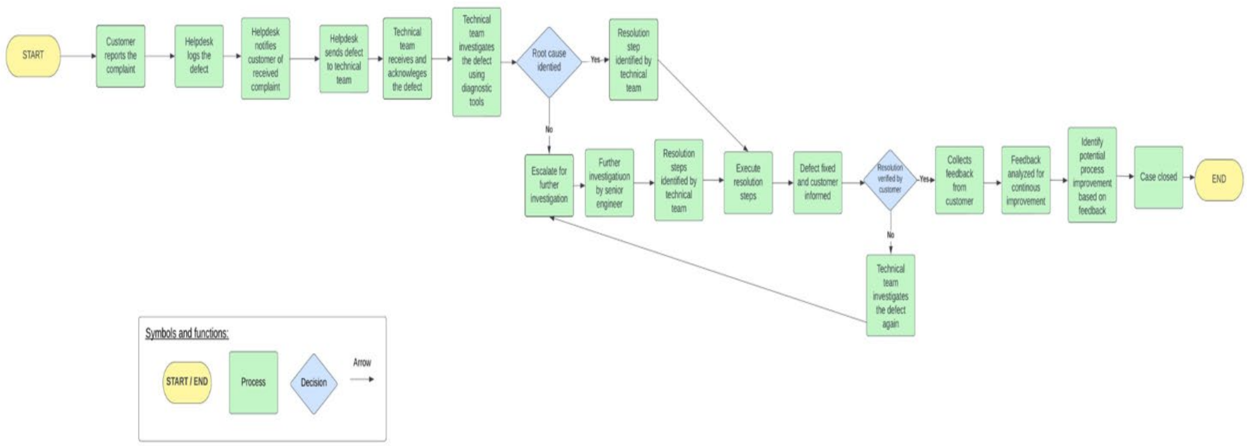


Figure 5**.** Detailed Process Map

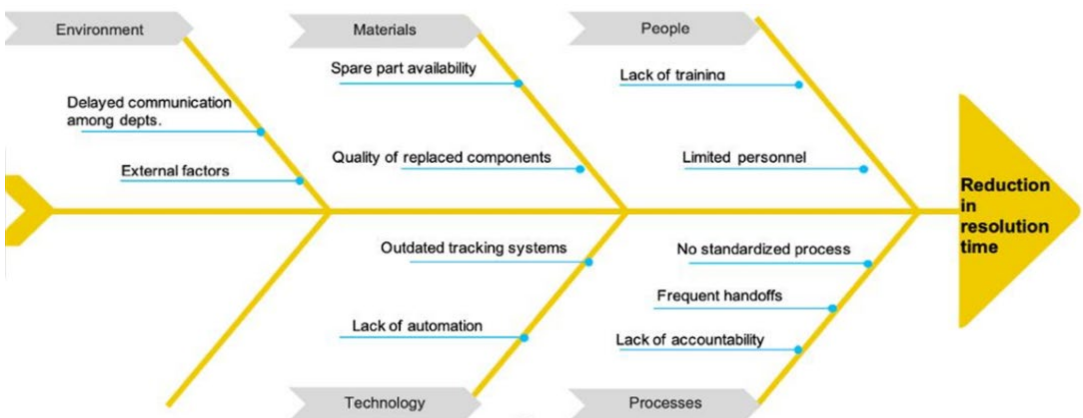


Figure 6. Fishbone Diagram

Addressing root causes through better communication, employee training, automation, and standardized workflows will significantly streamline defect resolution and enhance efficiency.

## 4.4 Improve

The Improve Phase implements solutions based on insights from the FMEA and Pugh Matrix. The FMEA identified the training program as the highest risk area, with an RPN of 160, highlighting the need for immediate action. Structured training programs were introduced, supported by incentives such as certifications and career growth opportunities, to address skill gaps and enhance staff efficiency. The Pugh Matrix analysis prioritized deploying a streamlined communication platform, with the highest improvement potential (+5 score), to reduce delays caused by interdepartmental communication issues.

Table 3. Pugh Matrix

| Criteria | Baseline (Training Program Implementation) | Modern Inventory System | Communication Platform | Standardized Workflow | Upgraded Tracking System |
|---|---|---|---|---|---|
| Cost | 0 | -1 | +1 | +1 | -1 |
| Implementation Time | 0 | -1 | +1 | 0 | -1 |
| Impact on Resolution Time | 0 | +1 | +1 | 0 | +1 |
| Ease of Implementation | 0 | -1 | +1 | 0 | 0 |
| Scalability | 0 | +1 | +1 | -1 | +1 |
| **Total Score** | **Baseline (0)** | **-1** | **+5** | **0** | **+1** |

Additionally, a modern inventory management system was proposed to address spare part unavailability, and standardized workflows were established to eliminate frequent handoffs and undefined responsibilities. These targeted interventions aim to reduce resolution time, improve collaboration, and stabilize the defect resolution process.

Table 4. FMEA

| Process Step | Failure Mode | Effect | Cause | Severity (S) | Occurrence (O) | Detection (D) | RPN (S x O x D) | Recommended Action |
|---|---|---|---|---|---|---|---|---|
| Training Program Implementation | Insufficient participation | Skills remain inadequate | Lack of incentives | 8 | 4 | 5 | 160 | Provide incentives like certifications, rewards, or career growth opportunities. |
| Inventory System Deployment | Implementation delays | Parts availability remains poor | Technical issues | 7 | 3 | 4 | 84 | Schedule regular maintenance checks and implement a robust issue-tracking system. |
| Communication Platform Adoption | Resistance to change | Continued delays in communication | Lack of training | 5 | 2 | 5 | 50 | Conduct user training sessions and offer ongoing support during the transition phase. |
| Workflow Standardization | Ambiguous guidelines | Miscommunication persists | Poor documentation | 6 | 3 | 5 | 90 | Develop clear SOPs, provide detailed documentation, and conduct regular reviews. |
| Tracking System Upgrade | Delayed deployment | Difficulty in tracking progress | Vendor or IT delays | 7 | 4 | 4 | 112 | Establish contingency plans and hold vendors accountable with stricter SLAs. |

The FMEA guided training program serves as the starting point to mitigate critical risks and establish process stability. Following this, pugh matrix guided the communication platform deployment will optimize efficiency and teamwork. These solutions collectively enhance the defect resolution process and align it with performance goals.

### 4.5 Control

The Control Phase ensures the implemented solutions maintain stability and deliver consistent results. An X-bar and R Chart was used to monitor the mean and variability of resolution times in subgroups. The chart highlights a gradual reduction in variability, particularly at the last point, indicating potential improvement. However, the process still requires continued monitoring to identify and address any anomalies, ensuring that performance aligns with the target resolution time. Standard operating procedures (SOPs) and regular audits are recommended to maintain improvements, alongside training updates to sustain employee efficiency.

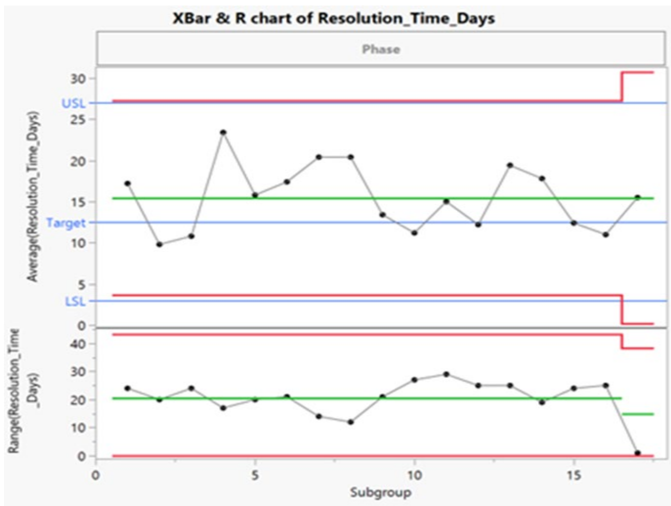


Figure 7. Control Chart on JMP

The control measures show promising improvements, as evidenced by reduced variability in the resolution process. The unusual drop in variability at the last point suggests potential improvement, which should be investigated further. Continuous monitoring through control charts and regular reviews is critical to sustaining these gains and ensuring long-term process stability.

## 5. Conclusion and Future Work

The implementation of the Six Sigma DMAIC methodology significantly improved the defect resolution process for Kensington wireless handheld keyboards. By systematically applying the Define, Measure, Analyze, Improve, and Control phases, key issues such as insufficient training and outdated communication methods were effectively addressed. Targeted interventions included the introduction of a comprehensive training program to close skill gaps and the deployment of a streamlined communication platform to enhance interdepartmental coordination and reduce delays. These improvements led to reduced resolution times, increased process stability, and enhanced customer satisfaction. Control measures, such as the X-bar and R chart, validated the reduction in variability and highlighted areas requiring ongoing monitoring. These changes successfully aligned the process with performance goals and established a foundation for sustained operational excellence. Future work will focus on expanding automation in inventory management and process tracking to minimize delays and ensure real-time updates. Employee development initiatives will include advanced training programs that incorporate new technologies and problem-solving techniques to enhance long-term efficiency. Additionally, the adoption of AI-driven communication tools will be explored to facilitate predictive issue resolution and improve interdepartmental collaboration. Continuous monitoring systems, integrated with control charts, will be established to proactively detect and address anomalies. Efforts will also prioritize scalability, extending the improved resolution processes to other product lines or departments for broader organizational benefits. Regular incorporation of customer feedback into process reviews will ensure alignment with customer expectations, driving sustained improvements and fostering innovation in the defect resolution process.

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## Biographies

**Prajyot Kavitake** is a dedicated master's student of Engineering Management at California State University, Northridge. With a strong academic foundation in civil engineering, having completed both diploma and bachelor's degrees in India, Prajyot brings a wealth of knowledge and experience to the fields of construction, supply chain, project management, and operations management. Having honed expertise in methodologies such as DMAIC and Lean Six Sigma, Prajyot has practical experience in lean project and operations management from work in India. This hands-on background, combined with an academic focus, enables a unique perspective on optimizing processes and driving efficiency. Prajyot is passionate about continuous learning and evolving, embracing every opportunity to grow personally and professionally. Guided by the belief that growth stems from consistent improvement, Prajyot aims to contribute to the advancement of sustainable and efficient practices in engineering and management. Other than academics Prajyot likes to go hiking and loves mother nature.

**Ganesh Gujjeti** is a master’s student of Engineering Management at California State University, Northridge. He has completed a bachelor’s degree in Electronics and Telecommunication Engineering. He was an intern at NPCIL Bank in India. A person who believes in data driven approach towards everything. Passionate about supply chain management and data analytics. Other than academics he loves to play cricket.

**Nachiket Pusadkar** is a master's student of Industrial/Engineering Management at CSUN, passionate about problem-solving and teamwork. With experience in data analysis and process improvement, enjoy applying creative solutions to challenges. Outside of academics, he loves playing football and is a dedicated Real Madrid supporter.

**Rahul Megharaj** is a master’s student of Engineering Management at California State University, Northridge, with a background in mechanical engineering. Specializing in supply chain management, project planning, and SolidWorks design. Also passionate about data analytics and enjoy using it to improve processes and find practical solutions.

**Sepideh Abolghasem** is an associate professor in the Department of Manufacturing Systems Engineering and Management at California State University at Northridge. Prior to this appointment, she was an associate professor in the Department of Industrial Engineering at the University of Los Andes, Bogotá, Colombia. She earned her B.Sc. degree in Industrial Engineering from Sharif University of Technology, Tehran, Iran and her M.Sc. and Ph.D. degrees in Industrial Engineering from University of Pittsburgh. Her main research interests span the integration of the disciplines of Operations Research and Materials Science. Much of her work has been focused on machining manufacturing process where she tries to improve the understanding of the interrelationships among the process parameters and the microstructure of the materials. Recently, she has been working on the application of machine learning techniques combined with simulation for material properties prediction. She has served as the faculty advisor at IISE and represented Latin America at INFORMS’ International Activities Committee.