BRACT’s

Vishwakarma Institute of Information Technology

Statistical Methods in Six Sigma

Assignment_05: DMAIC methodology and statistical method implementation in manufacturing. (Case study of General Electrics)

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1. Introduction

Manufacturing industries face constant challenges of quality assurance, cost reduction, and process optimization. General Electric (GE), a global leader in manufacturing and technology, has historically relied on **Six Sigma methodologies** to achieve operational excellence. GE was one of the earliest corporations to institutionalize Six Sigma under the leadership of Jack Welch in the 1990s, saving
billions of dollars annually through systematic process improvements.

This assignment explores how GE applied the **DMAIC (Define, Measure, Analyze, Improve, Control)**
framework and statistical methods in manufacturing to reduce defects, increase productivity, and improve customer satisfaction.

2. Objectives

The key objectives of this study are:

1. To establish a conceptual understanding of Six Sigma and the DMAIC methodology in manufacturing.
2. To analyze process inefficiencies in GE's manufacturing workflows.
3. To demonstrate how statistical methods enhance decision-making in quality control.
4. To evaluate GE's implementation of Six Sigma and its measurable impact.
5. To explore scalability of GE's practices to other manufacturing industries.

3. Theoretical Framework

3.1 What is Six Sigma?

Six Sigma is a **data-driven methodology** aimed at reducing process variation and defects to as low as
3.4 defects per million opportunities (DPMO). In manufacturing, this translates into higher yield, consistent quality, and reduced rework costs.

3.2 DMAIC Framework

The DMAIC methodology forms the backbone of GE's process improvement strategy:

Phase	Activities	Manufacturing Tools
Define	Identify customer needs, defects, and project scope	SIPOC, Project Charter, VOC

Measure	Collect baseline data on defects, cycle times, throughput	Control Charts, Pareto Analysis, Time Studies
Analyze	Identify root causes of process inefficiencies	Fishbone, Regression, Hypothesis Testing, ANOVA
Improve	Implement solutions to eliminate root causes	DOE, Kaizen, Lean Tools, Poka-Yoke
Control	Sustain improvements through monitoring	SPC, Dashboards, SOPs

3.3 Why Six Sigma in Manufacturing?

Manufacturing demands high precision and reliability. Even minor deviations can lead to **waste, recalls, or customer dissatisfaction.** GE recognized that integrating Six Sigma into production not only improved product quality but also enhanced financial performance.

4. General Electric Case Study: Background and Context

4.1 Problem Diagnosis

GE Aviation’s engine manufacturing division identified recurring challenges:

- **Defect Rate:** Over 7% defect rate in turbine blade production.
- **Cycle Time Delays:** Average of 28 days to deliver critical components.
- **Rework Costs:** Nearly $1.2 million annually in scrap and rework.

These inefficiencies directly impacted customer satisfaction and production costs.

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5. DMAIC Application at General Electric

5.1 Define Phase

- **Project Charter:** Reduce turbine blade defect rate from 7% → ≤2% and cycle time from 28 days → ≤15 days.
- **Stakeholders:** Manufacturing engineers, quality inspectors, suppliers, and end-customers.
- **VOC Findings:** Customers demanded faster delivery, higher durability, and minimal delays.

5.2 Measure Phase

Data was collected from 500 production batches over 6 months. Key Baseline Metrics:

KPI	Baseline	Target
Defect Rate	7%	2%
Cycle Time	28 days	15 days
Rework Cost	$1.2M	<$0.5 M
Yield Rate	92%	98%

5.3 Analyze Phase

Statistical tools identified root causes:

- **Pareto Analysis:** 80% of defects were from heat-treatment inconsistencies.
- **Regression Analysis:** Strong correlation between furnace temperature fluctuations and defect rate.
- **FMEA Results:** "Improper alloy cooling" scored highest in Risk Priority Number (RPN).

5.4 Improve Phase

GE implemented multiple improvement strategies:

- **Automated Temperature Monitoring:** Sensors reduced furnace variation by 70%.
- **Design of Experiments (DOE):** Optimized heat-treatment parameters.
- **Lean Practices:** Reduced handling steps by 30%.
- **Poka-Yoke:** Introduced fixtures preventing incorrect

blade alignment. Results from pilot plants:

Metric	Before	After	% Improvement
Defect Rate	7%	2%	↓71%
Cycle Time	28 d	14 d	↓50%
Rework Cost	$1.2M	$0.4M	↓67%
Yield Rate	92%	98%	↑6%

5.5 Control Phase

GE sustained improvements through:

- **SPC Charts** to monitor furnace variation.
- **Standard Work Instructions (SWIs).**
- **Monthly Six Sigma audits.**
- **Digital Dashboards** for real-time KPI tracking.

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6. Measurable Outcomes & ROI

6.1 Quantitative Benefits

Metric	Baseline	Post-DMAIC	% Change	Annual Savings
Defect Rate	7%	2%	↓71%	$3.2M saved
Cycle Time	28 days	14 days	↓50%	+$5M revenue
Rework Costs	$1.2M	$0.4M	↓67%	$0.8M saved
Yield Rate	92%	98%	↑6%	↑Customer

				Trust

6.2 Qualitative Improvements

- **Improved Reliability:** Aircraft engines met stringent aviation standards.
- **Employee Engagement:** Training improved problem-solving culture.
- **Customer Satisfaction:** On-time delivery and reduced recalls boosted GE's reputation.

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7. Scalability and Recommendations

7.1 Scalability

GE's approach can be applied across industries (automotive, electronics, energy) with process- specific adaptations.

7.2 Recommendations

Strategy	Actionable Insight
Digital Twins	Simulate production processes before scaling changes.
Predictive Maintenance	Use IoT sensors to prevent machine breakdowns.
Tiered Training	Green Belts for shop-floor staff; Black Belts for managers.
Supplier Quality Integration	Extend Six Sigma to vendor processes.

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8. Limitations and Future Directions

8.1 Limitations

- **High Initial Investment:** Sensors, DOE trials, and automation required $2M investment.
- **Change Resistance:** Initial reluctance among operators to adopt new protocols.

8.2 Future Scope

- Combining **Lean + Six Sigma** for further waste elimination.
- Expanding predictive analytics across GE's global plants.
- Exploring **AI-driven quality inspection** for zero-defect manufacturing.

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9. Discussion Questions

1. How can reducing defect rates from 7% to 2% impact GE's long-term competitiveness?
2. Can smaller manufacturers replicate GE's Six Sigma model with limited budgets?
3. Debate: "Statistical methods are more effective than automation in improving manufacturing quality."

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10. Conclusion

The case study of GE demonstrates how **DMAIC methodology** and **statistical methods** can revolutionize manufacturing processes. By addressing root causes such as furnace variability and inefficient workflows, GE not only reduced defects and cycle times but also achieved substantial cost savings and improved customer trust.

This study proves that Six Sigma is not just a quality initiative but a **strategic driver of business excellence**. With continued innovation, integration of IoT and AI, and focus on data-driven decisions, Six Sigma can pave the way for **zero-defect, highly efficient manufacturing systems worldwide**.
