Optimizing Component Preparation Area's PTS Visualization Tools for Enhanced Manufacturing Performance

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Abstract *— This Design Project presents the development and optimization of a Performance-to-Standard dashboard for monitoring manufacturing process performance. Traditional spreadsheet-based dashboards relied on manual data entry, lacked real-time integration, limiting the ability to identify process variability effectively. The proposed solution integrates data from multiple operational systems into a Power BI platform, enabling automated monitoring of key performance indicators such as Cycle Time Performance and Pass/Failed Cycles. The system enhances data visualization and supports real-time analysis of process efficiency across equipment, loads and production steps. Results demonstrate improved operational visibility, enhanced identification of variability and strong stakeholder acceptance. The implementation supports continuous improvement initiatives and establishes a scalable framework for data-driven monitoring in manufacturing environments.*

Keywords *— Continuous Improvement, Data Visualization, DMAIC, Manufacturing Performance, Power BI, Process Variability, PTS.*

INTRODUCTION

Manufacturing systems require reliable and timely access to operational data to maintain efficiency and ensure product quality. In highly dynamic production environments, the ability to monitor performance in real time is essential for identifying inefficiencies, detecting variability and enabling rapid decision-making.

Traditional monitoring systems often rely on spreadsheet-based dashboards, which present several limitations. These tools typically require manual data entry; they lack integration with real-time data sources and provide limited visualization capabilities. As production complexity increases, these limitations reduce the effectiveness of performance monitoring and delay corrective actions.

The purpose of this project is to develop an integrated Performance-to-Standard (PTS) dashboard using Power BI to improve manufacturing performance monitoring. The system integrates multiple data sources and provides real-time visualization of key performance indicators, enabling stakeholders to monitor variability and support continuous improvement initiatives. Figure 1 illustrates the operational environment monitored through the PTS dashboard system.

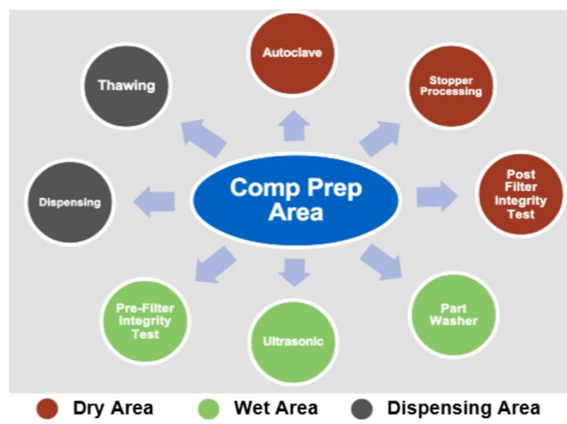


Figure 1
Process Environment Overview

The process environment consists of multiple operational areas and equipment groups involved in component preparation activities, including dry, wet, and dispensing-related processes. These operational stages generate critical performance data used to evaluate process efficiency, cycle execution, and variability across production activities. Figure 1 provides context for the manufacturing environment in which the dashboard system was implemented and highlights the complexity of monitoring performance across interconnected operational processes.

BACKGROUND

Data visualization plays a critical role in modern manufacturing systems by transforming raw data into actionable insights. Advanced visualization tools enable organizations to monitor key performance indicators, detect trends, and respond quickly to process deviations.

The integration of Statistical Process Control (SPC) techniques within visualization platforms enhances the ability to monitor process stability and identify variability. SPC tools provide methods to analyze process behavior over time, allowing early detection of deviations before they escalate into significant issues.

Additionally, Lean and Six Sigma methodologies emphasize continuous improvement through the reduction of variability and elimination of inefficiencies. These approaches rely heavily on accurate data and real-time monitoring to support decision-making and process optimization.

PROBLEM STATEMENT

Spreadsheet-based dashboards present several limitations in modern manufacturing environments:

- Lack of real-time data integration
- Manual data processing and risk of human error
- Limited visualization capabilities
- Difficulty in identifying variability across processes

These limitations reduce operational visibility and hinder the ability to detect inefficiencies and respond promptly to performance deviations. As a result, decision-making is delayed, and opportunities for process improvement may be missed.

The integration of real-time data and advanced visualization platforms provides a powerful framework for improving manufacturing performance and achieving operational excellence.

METHODOLOGY

This project follows the DMAIC (Define, Measure, Analyze, Improve, Control) framework to guide the development and evaluation of the dashboard system. The methodology was applied to organize data integration, dashboard development and validation activities, ensuring alignment between the identified problem and the implemented solution. This structured approach supports a systematic transition from traditional monitoring tools to an integrated data-driven system, enabling improved visibility, performance tracking and continuous improvement within the manufacturing process. As part of the implementation phase, a data integration architecture was developed to support the Power BI dashboard system, as shown in Figure 2.

Operational data is collected from multiple source systems and processed through intermediate transformation and preparation layers before being integrated into the visualization platform. This structure enables consolidation of operational information into a centralized dashboard environment capable of supporting real-time monitoring and analysis. The architecture improves data accessibility, reduces reliance on manual data consolidation, and enhances the reliability and consistency of performance reporting across operational activities.

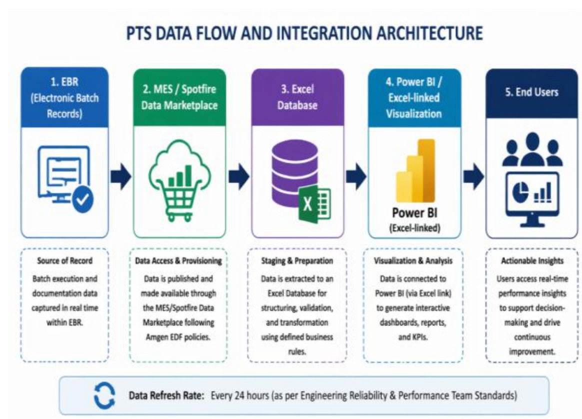


Figure 2
Data Integration Architecture

Define Phase

The define phase focused on identifying the limitations of existing monitoring tools and establishing project objectives. The primary goal was to develop a system capable of integrating data from multiple sources and providing real-time performance visibility.

Measure Phase

During the measure phase, operational data was collected from existing systems and analyzed to establish baseline performance metrics. This phase helped identify gaps in data availability, integration and visualization capabilities.

Analyze Phase

The analyze phase focused on identifying inefficiencies and variability within the collected data. The analysis revealed variations across equipment, process steps and production loads that were not easily detectable using spreadsheet-based tools.

Improve Phase

In the improve phase, a Power BI dashboard was developed to integrate and visualize operational data. The system was designed to provide real-time monitoring of key performance indicators and support identification of performance deviations.

Control Phase

The control phase involved validating the system through stakeholder feedback and continuous monitoring. Surveys were conducted to evaluate usability, data accuracy and effectiveness of the dashboard.

Data Integration

Figure 3 illustrates the DMAIC methodology framework applied throughout the development and evaluation of the Performance-to-Standard (PTS) dashboard system. The framework provided a structured approach for identifying limitations within the existing monitoring process, collecting and analyzing operational data, developing the dashboard solution, and validating system effectiveness through stakeholder feedback. Each phase of the DMAIC methodology contributed to the systematic transition from traditional spreadsheet-based monitoring tools to an integrated data-driven visualization system. The framework also supported alignment between problem identification, solution implementation, and continuous improvement objectives within the manufacturing environment.

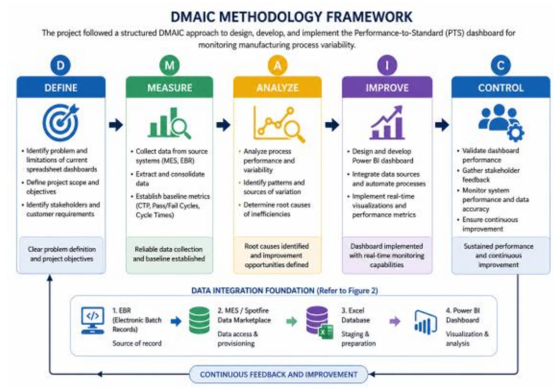


Figure 3
DMAIC Methodology Framework

Performance Metrics

Cycle Time Performance (CTP) is defined as:

CTP (%) = (Average Cycle Time ÷ Standard Cycle Time) × 100. Where:

- ***Average Cycle Time*** represents the observed cycle time
- ***Standard Cycle Time*** represents the predefined expected duration

A value of 100% indicates that the process is operating at the defined standard. Values greater than 100% indicate that the process is performing slower than expected, while values below 100% indicate that the process is performing faster than the standard. This formula allows direct evaluation of process deviation from standard performance, making it suitable for variability monitoring in manufacturing environments.

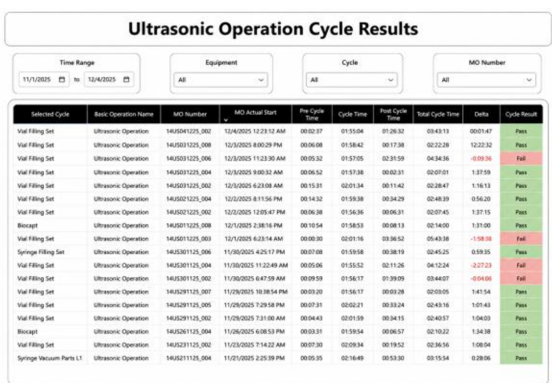
RESULTS & DISCUSSION

The following section presents the results obtained from the implementation and evaluation of the Performance-to-Standard (PTS) dashboard system. The analysis focuses on operational performance, variability monitoring, stakeholder validation and the comparison between traditional spreadsheet-based dashboards and the integrated Power BI solution.

Cycle Time Performance

The implemented dashboard provides real-time visualization of cycle time performance across equipment, process steps and production loads. This allows stakeholders to monitor performance relative to defined standards and identify deviations efficiently.

The primary purpose of the dashboard is to monitor operational variability across these dimensions, enabling real-time identification of inefficiencies and supporting continuous improvement initiatives. Figure 4 presents the Power BI dashboard used to visualize cycle-level performance metrics, including pre-cycle, cycle and post-cycle times for evaluation against defined standard values. The dashboard enables real-time monitoring of operational performance across multiple equipment groups and production loads.



Selected Cycle	Basic Operation Name	MO Number	MO Actual Start	Pre Cycle Time	Cycle Time	Post Cycle Time	Total Cycle Time	Delta	Cycle Result
Vial Filling Set	Ultrasonic Operation	14US041225_002	12/4/2025 12:23:12 AM	00:02:37	01:55:04	01:26:32	03:43:13	00:01:47	Pass
Vial Filling Set	Ultrasonic Operation	14US031225_008	12/3/2025 8:00:29 PM	00:06:08	01:58:42	00:17:38	02:22:28	12:22:32	Pass
Vial Filling Set	Ultrasonic Operation	14US031225_006	12/3/2025 11:23:30 AM	00:05:32	01:57:05	02:31:59	04:34:36	-0:09:36	Fail
Vial Filling Set	Ultrasonic Operation	14US031225_004	12/3/2025 9:00:32 AM	00:06:52	01:57:38	00:02:31	02:07:01	1:37:59	Pass
Vial Filling Set	Ultrasonic Operation	14US031225_002	12/3/2025 6:23:08 AM	00:15:31	02:01:34	00:11:42	02:28:47	1:16:13	Pass
Vial Filling Set	Ultrasonic Operation	14US021225_004	12/2/2025 8:11:56 PM	00:14:32	01:59:38	00:34:29	02:48:39	0:56:20	Pass
Vial Filling Set	Ultrasonic Operation	14US021225_002	12/2/2025 12:05:47 PM	00:06:38	01:56:36	00:06:31	02:07:45	1:37:15	Pass
Biocapt	Ultrasonic Operation	14US011225_008	12/1/2025 2:38:16 PM	00:10:54	01:58:53	00:08:13	02:14:00	1:31:00	Pass
Vial Filling Set	Ultrasonic Operation	14US011225_003	12/1/2025 6:23:14 AM	00:00:30	02:01:16	03:36:52	05:43:38	-1:58:38	Fail
Syringe Filling Set	Ultrasonic Operation	14US301125_006	11/30/2025 4:25:17 PM	00:07:08	01:59:58	00:38:19	02:45:25	0:59:35	Pass
Vial Filling Set	Ultrasonic Operation	14US301125_004	11/30/2025 11:22:49 AM	00:05:06	01:55:52	02:11:26	04:12:24	-2:27:23	Fail
Vial Filling Set	Ultrasonic Operation	14US301125_002	11/30/2025 6:47:59 AM	00:09:59	01:56:17	01:39:09	03:44:07	-0:04:06	Fail
Vial Filling Set	Ultrasonic Operation	14US291125_007	11/29/2025 10:38:54 PM	00:03:20	01:56:17	00:03:28	02:03:05	1:41:54	Pass
Vial Filling Set	Ultrasonic Operation	14US291125_005	11/29/2025 7:29:58 PM	00:07:31	02:02:21	00:33:24	02:43:16	1:01:43	Pass
Vial Filling Set	Ultrasonic Operation	14US291125_002	11/29/2025 7:31:00 AM	00:04:43	02:01:59	00:34:15	02:40:57	1:04:03	Pass
Biocapt	Ultrasonic Operation	14US261125_004	11/26/2025 6:08:53 PM	00:03:31	01:59:54	00:06:57	02:10:22	1:34:38	Pass
Vial Filling Set	Ultrasonic Operation	14US231125_002	11/23/2025 7:14:22 AM	00:07:30	02:09:34	00:19:52	02:36:56	1:08:04	Pass
Syringe Vacuum Parts L1	Ultrasonic Operation	14US211125_004	11/21/2025 2:25:39 PM	00:05:35	02:16:49	00:53:30	03:15:54	0:28:06	Pass

Figure 4
Cycle Time Performance Dashboard

Pass/Failed Cycles

The system includes a classification mechanism that identifies whether cycles meet predefined performance standards. Results indicate that most cycles operate within defined standard cycle time limits, demonstrating stable process performance. This classification provides a clear and intuitive method for evaluating operational efficiency and identifying areas requiring attention.

Figure 5 illustrates the distribution of passed and failed cycles across operational processes (Totals per Load/Cycle in this case). The visualization supports rapid identification of deviations from expected performance and provides a simplified representation of process efficiency.

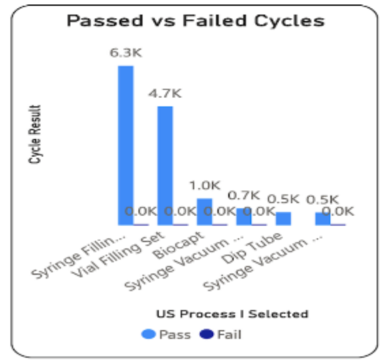
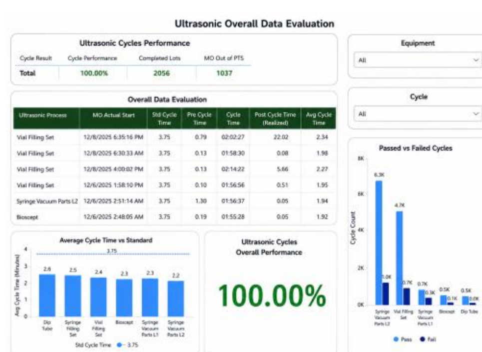


Figure 5
Pass/Failed Cycles Distribution

Variability Monitoring

The dashboard enables effective monitoring of variability across equipment, loads and process steps. This capability allows stakeholders to detect patterns and inconsistencies that were previously difficult to identify using manual tools. By visualizing variability, the system supports proactive identification of inefficiencies and enables targeted improvement efforts.

To further validate the effectiveness of the implemented system, stakeholder feedback was collected and analyzed, as shown in Figure 6. The figure displays the overall data evaluation dashboard used to monitor variability across equipment, production loads and process steps. The dashboard integrates performance indicators, cycle time trends and distribution metrics to support identification of operational inconsistencies and improvement opportunities.



Cycle Result	Cycle Performance	Completed Lots	MO Out of PTS
Total	100.00%	2056	1037

Ultrasonic Process	MO Actual Start	Std Cycle Time	Pre Cycle Time	Cycle Time	Post Cycle Time (Realized)	Avg Cycle Time
Vial Filling Set	12/8/2025 6:35:16 PM	3.75	0.79	02:02:27	22.02	2.34
Vial Filling Set	12/8/2025 6:30:33 AM	3.75	0.13	01:58:30	0.08	1.98
Vial Filling Set	12/8/2025 4:00:02 PM	3.75	0.13	02:14:22	5.66	2.27
Vial Filling Set	12/6/2025 1:58:10 PM	3.75	0.10	01:56:56	0.51	1.95
Syringe Vacuum Parts L2	12/6/2025 2:51:14 AM	3.75	1.30	01:56:37	0.05	1.94
Biocapt	12/6/2025 2:48:05 AM	3.75	0.19	01:55:28	0.05	1.92

Figure 6
Variability Monitoring Dashboard

Stakeholder Feedback

Stakeholder feedback was collected through surveys involving management, specialists and operational personnel (see Figure 7). The results indicate:

- High usability and ease of interpretation
- Strong functionality and system acceptance
- Effective monitoring of variability
- Positive support for continuous improvement
- Feedback also identified opportunities for improvement, including:
- Increased transparency in data calculations
- Enhanced alert functionality
- More frequent data refresh intervals
- These findings confirm the effectiveness of the system while highlighting areas for further refinement.

This demonstrates strong system acceptance across usability, functionality and variability monitoring categories, supporting the effectiveness of the implemented dashboard solution.

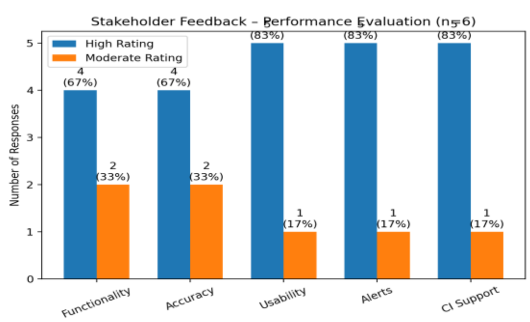


Figure 7
Stakeholder Feedback Results

System Comparison

Compared to spreadsheet-based dashboards, the Power BI system provides:

- Automated data integration
- Improved visualization capabilities
- Enhanced detection of process variability
- Faster access to performance insights
- A significant improvement in operational monitoring capabilities and effective utilization of data for decision-making.

As illustrated in Figure 8, the transition from spreadsheet-based dashboards to an integrated Power BI system represents a significant advancement in manufacturing performance monitoring. The previous approach relied on manual data consolidation and static visualizations, limiting the ability to detect trends and identify variability across processes. In contrast, the Power BI dashboard enables automated data integration, real-time performance tracking and dynamic visualization of key metrics such as cycle time performance and pass/fail classification.

This transformation allows stakeholders to quickly identify deviations, monitor variability across equipment and production loads and make informed decisions based on current operational data. The comparison highlights the shift from reactive reporting to proactive monitoring, demonstrating how the implemented solution enhances visibility, improves data accuracy and supports continuous improvement initiatives.

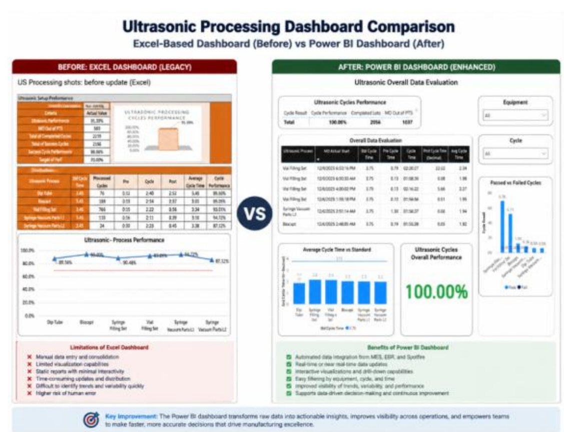


Figure 8
Dashboard System Comparison

Statistical analysis of stakeholder feedback further validated the effectiveness of the implemented system. A total of six stakeholder responses were analyzed during the validation phase. Approximately 83% of respondents provided high ratings in usability, alert effectiveness and support for continuous improvement initiatives, while 67% rated data accuracy as very accurate compared to previous reporting methods. In addition, the majority of participants indicated that the dashboard effectively supports variability monitoring across equipment, loads and process steps.

These findings demonstrate strong overall acceptance of the dashboard and support its practical applicability as a real-time variability monitoring and decision-support tool. The consistency of positive responses across multiple evaluation categories reinforces the reliability of the implemented system and confirms its contribution to improved operational visibility and data-driven decision-making.

Overall, the implemented dashboard functions not only as a visualization tool, but as a data-driven monitoring system that enables proactive management of process performance and operational variability.

CONCLUSIONS

The developed Performance-to-Standard dashboard significantly improves the ability to monitor manufacturing performance by providing real-time visibility into key operational metrics. By integrating data from multiple sources into a centralized visualization platform, the system eliminates the limitations associated with manual data handling and enhances the accuracy and accessibility of performance information.

The dashboard enables effective monitoring of process variability across equipment, production loads and process steps. This capability allows stakeholders to identify deviations from expected performance more efficiently and supports the implementation of targeted continuous improvement initiatives. The ability to visualize variability in real time represents a critical advancement compared to traditional monitoring approaches.

Furthermore, the system improves decision-making by providing timely and actionable insights. Stakeholders are no longer required to rely on delayed or manually compiled data, enabling faster responses to performance issues and improving overall operational efficiency. This shift from static reporting to dynamic monitoring enhances both the reliability and effectiveness of performance evaluation processes.

The results demonstrate that integrating real-time data visualization tools into manufacturing environments can significantly improve operational performance. The dashboard not only enhances visibility but also supports proactive management of process variability, enabling organizations to identify inefficiencies early and implement corrective actions more effectively.

Overall, the implemented solution functions as a data-driven monitoring framework rather than a static reporting tool, providing a scalable and adaptable platform for performance management in manufacturing systems.

Future Work

- Future improvements may include the development of advanced alert systems capable of identifying performance deviations in real time and notifying stakeholders based on predefined thresholds. This would enhance the system's ability to support proactive decision-making.
- Increasing the *data refresh* frequency is another key opportunity. Reducing the refresh interval from the current standard to shorter timeframes, such as 8 to 12 hours, would provide more up-to-date insights and improve responsiveness to operational changes.
- Additional visualization capabilities may also be implemented to provide deeper insights into process performance. These may include more granular analysis at the shift, operator, or equipment level, allowing for more targeted identification of inefficiencies.
- The integration of additional data sources represents another area for expansion. Incorporating more systems into the dashboard would provide a more comprehensive view of manufacturing performance and further improve data-driven decision-making capabilities.
- The implementation of predictive analytics is a potential long-term enhancement. By

leveraging historical data and statistical modeling, the system could identify potential performance issues before they occur, enabling a more proactive approach to process management.

- Finally, the expansion of the dashboard to cover additional operational areas would further increase its impact. Extending the solution to other process areas would support broader performance monitoring and contribute to the standardization of data visualization practices across manufacturing operations.

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