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Lean Six Sigma: Optimize Material Utilization Tobyhanna Army Depot

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Abstract: Tobyhanna Army Depot supports DoW readiness by sustaining C5ISR systems, making efficient material use critical. This project applied Lean Six Sigma to reduce long-dwell material—unused raw material for over 12 months. Through process mapping, data analysis, and pilot testing, we found that 48–50% of reviewed materials had viable substitution candidates, revealing substantial reusable inventory with limited visibility. The pilot showed measurable impact, including ~$4,600 in avoided repurchasing within a small sample and over $50,000 in potential savings when scaled. To address this, we recommend implementing a Power BI dashboard and a standardized reuse workflow to improve visibility and enable engineering validation for substitutions. These solutions target key gaps in tracking, return compliance, and cross-referencing across Federal Supply Classes. Overall, improving visibility and standardizing reuse processes can significantly reduce long-dwell inventory, lower procurement costs, and enhance operational efficiency at Tobyhanna.

Keywords: Lean Six Sigma, DMAIC, System Engineering, Tobyhanna Army Depot, West Point

1. Literature Review

Lean Six Sigma is a structured process improvement methodology that combines Lean principles focused on waste reduction with Six Sigma techniques aimed at reducing variation and improving process consistency (George et al., 2005; CFI Team, 2022). Originally developed for manufacturing, Lean Six Sigma has been widely adopted across logistics, healthcare, defense, and government organizations due to its flexibility and emphasis on data driven decision making (Pepper & Spedding, 2010; U.S. Army, 2011). Central to Lean Six Sigma is the DMAIC framework, which consists of five phases: Define, Measure, Analyze, Improve, and Control. This framework provides a disciplined approach for identifying root causes of inefficiency and sustaining process improvements over time (George et al., 2005).

Lean methodology focuses on eliminating activities that do not add value from the customer's perspective (ASQ, n.d.). The core Lean principles of value, value stream, flow, pull, and perfection guide organizations in aligning processes with customer needs while minimizing waste (Maarof & Mahmud, 2016). Long-dwell inventory is one of the costliest forms of waste, particularly in complex logistics environments, because it ties up capital, consumes storage capacity, and often obscures underlying process problems (Chopra & Sodhi, 2004). In high mix, low volume production systems, excess and long dwell inventory can accumulate when material reuse is limited and visibility across processes is insufficient (Blome & Schoenherr, 2011).

Six Sigma complements Lean by emphasizing process stability and consistency through measurement and statistical analysis (Brook, 2022). By focusing on variation reduction, Six Sigma ensures that improvements address root causes rather than symptoms (Kumar et al., 2018). The DMAIC framework operationalizes this approach by requiring teams to define the problem and scope clearly, establish baseline performance, analyze data to identify sources of variation, implement targeted improvements, and introduce controls to sustain gains (George et al., 2005). Prior research highlights that strict adherence to DMAIC tollgate requirements is essential for maintaining scope discipline and achieving measurable results, particularly in large organizations with multiple stakeholders (Berardinelli, 2012).

Inventory management has been a common application area for Lean Six Sigma because of its direct impact on cost, throughput, and operational readiness (Snee, 2010). Studies indicate that poor inventory visibility and inconsistent material handling practices contribute significantly to excess stock and long-dwell inventory (Chopra & Sodhi, 2004). In systems that rely on classification structures such as Federal Stock Classes, functionally interchangeable materials may remain underutilized due to a lack of cross referencing, leading to unnecessary repurchasing and accumulation of idle inventory (Chu et al., 2016).

Within military logistics organizations, Lean Six Sigma has been widely used to improve material flow and reduce costs under increasing budget and readiness constraints (U.S. Army, 2011). The Department of Defense has promoted Lean Six Sigma adoption across depot level maintenance and supply chain operations to improve efficiency and resource utilization (U.S. Army, 2011). Prior implementations at Army depots have resulted in reduced repair cycle times, improved schedule adherence, and significant cost savings through better use of existing inventory (Clary & Tuten, 2012). These outcomes emphasize the importance of standardized processes, accurate data, and shared visibility in managing complex material systems.

The literature also recognizes that not all improvement opportunities can be addressed within the scope of a single Lean Six Sigma project (Pepper & Spedding, 2010). Improvements that require policy changes, information system modifications, or shifts in decision authority often exceed the control of project teams and must be addressed at higher organizational levels (Pepper & Spedding, 2010). As a result, effective Lean Six Sigma projects distinguish between immediate improvements that can be implemented within existing constraints and longer-term opportunities that are documented for future consideration (Snee, 2010). This distinction allows teams to deliver meaningful results while maintaining alignment with project scope and authority.

Overall, existing research supports the application of Lean Six Sigma as an effective methodology for improving inventory utilization and reducing long dwell material in complex logistics environments (George et al., 2005; Brook, 2022). By applying the DMAIC framework to improve visibility, standardize processes, and identify root causes of excess inventory, organizations can achieve measurable financial and operational benefits (Kumar et al., 2018). These findings provide the foundation for applying Lean Six Sigma to the optimization of raw material utilization within the Automated Storage and Retrieval System at Tobyhanna Army Depot.

2. Methodology

2.1 Define Phase

2.1.1 Problem and Goal Statement

Early meetings revealed that Tobyhanna staff were describing the same issue using inconsistent terminology, creating confusion across departments. To address this, the team first established a standardized definition: "long-dwell material," defined as material unused and stored for over 12 months. This alignment enabled clearer analysis and communication.

The problem statement identifies that Tobyhanna is not optimizing raw material use—particularly aluminum, steel, cable, and wire—due to unused materials not being returned and instead treated as scrap, resulting in 10–20% dead stock, wasted space, and increased costs. The goal is to reduce long-dwell inventory in the ASRS by 10% and decrease related cycle counts by 10% by March 2026.

2.1.2 SIPOC Map

The SIPOC map was created to address inefficiencies in how long-dwell material is requested, tracked, reused, and disposed of, as stakeholders had unclear and inconsistent responsibilities. By mapping the process from inputs to outputs, it established a shared baseline, clarified key touchpoints, and highlighted gaps in visibility and accountability. This structured view connected operational issues to measurable metrics and provided a common operating picture, enabling targeted improvements in quality, speed, and cost.

2.1.3 Process Map

Before mapping the process, it was clear that departments understood their roles but lacked visibility into the full material lifecycle, causing delays and rework to be seen as isolated issues. The team mapped the end-to-end process—from customer requirement to final disposition—to understand how long-dwell material originated and moved (or stalled) through the system. This visualization highlighted key friction points, including lead times, return delays, and accountability gaps, as well as system touchpoints like ASRS, PRRT, and LMP. Ultimately, the process map provided a shared understanding of material flow and identified opportunities to improve return compliance, visibility, and reduce long-dwell inventory.

2.1.4 Voice of Customer / Voice of Business

Before building the VOC/VOB table, it was clear the problem required balancing customer expectations (timely, spec-compliant products) with business needs (inventory accuracy, cost control, and material reuse). These priorities were often discussed separately, making them hard to translate into measurable requirements.

By structuring stakeholder input into a VOC/VOB framework, the team defined Critical Customer Requirements (CCR) and Critical Business Requirements (CBR), linking issues like poor visibility and excess inventory to measurable targets such as timely system updates, increased reuse, and reduced dead stock. This alignment created a clear framework to evaluate performance across quality, speed, and cost.

2.2 Measure Phase

2.2.1 Estimated Financial & Operational Benefits

A financial analysis was conducted to estimate the impact of reducing long-dwell inventory across key FSC groups—8340 (Tents and Tarpaulins), 5935 (Electrical Connectors), and 5985 (Antennas and Waveguides)—which together accounted for over $18 million in long-dwell material value. However, further discussions revealed that FSC 8340 was intentionally retained due to Army guidance for future use, placing it outside the project's definition of long-dwell material and scope.

Using a conservative 10% reduction target aligned with the project goal, the team estimated potential savings of approximately $1.82 million across the remaining relevant categories. These savings come primarily from reduced repurchasing and improved utilization of existing materials. Overall, the analysis demonstrates that improving visibility, return compliance, and reuse processes can yield significant cost savings while enhancing operational efficiency.

2.2.2 Data Collection Plan

As stakeholder engagement progressed, inconsistent terminology across departments emerged as a key barrier, with teams using different acronyms and definitions for the same systems and processes. To reduce confusion, a standardized set of operational definitions and acronyms was developed, ensuring a shared understanding across stakeholders.

A critical outcome was formally defining "long-dwell material" as any material unused for 365 days, providing a consistent way to identify and measure the issue. Additional terms—such as FSC classifications, ASRS, and LMP—were also standardized, creating a common vocabulary that improved communication, reduced ambiguity, and supported more effective discussions on inventory management and material reuse.

2.2.3 Baseline Statistics

After defining the problem and mapping the process, a structured data collection plan was developed to ensure analysis was based on reliable, consistent data across systems like LMP, ASRS, procurement, and shop operations. Key metrics were identified to capture both the scale and drivers of long-dwell inventory, including total cost, storage utilization, scrap cost, excess inventory, consumption rates, purchase volumes, and return compliance.

For each metric, the plan specified clear definitions, data sources, extraction methods, and responsible personnel. It also outlined sample sizes, stratification factors (e.g., material type, vendor, shop, location), and how the data would be used analytically. This structured approach enabled consistent measurement, identification of patterns, and direct linkage between operational behaviors and impacts on cost, storage, and material availability.

2.3 Analyze Phase

2.3.1 Ishikawa Diagram

To identify root causes of long-dwell material, a collaborative cause-and-effect analysis was conducted onsite with Tobyhanna personnel. Potential contributors were brainstormed and organized into categories such as materials, manpower, methods, measurement, equipment, and environment, ensuring input from multiple departments and perspectives.

These causes were then prioritized using a weighted voting system, where participants assigned points (5, 3, or 1) to the factors they believed had the greatest impact. The results were tallied to identify the most significant contributors, allowing the team to narrow a broad set of possibilities into a prioritized list of root causes grounded in operational experience.

2.3.2 FMEA

The Failure Modes and Effects Analysis (FMEA) identified the highest-risk issues driving long-dwell material based on Risk Priority Numbers (RPN). The most critical failure modes included inventory systems that do not support material reuse, production timelines prioritizing output over material returns, and operating conditions that discourage returns.

These issues reduce visibility of reusable materials, delay their return, and weaken accountability, causing usable inventory to remain idle or be treated as scrap—leading to increased storage use and unnecessary repurchasing. Additional risks included the lack of standardized procedures for partial material returns and the absence of system prompts to flag reusable inventory.

Overall, the analysis showed that long-dwell inventory is driven more by process, system, and visibility gaps than by material shortages. The FMEA results provided a prioritized set of risks that directly informed root cause analysis and guided targeted improvements in the Improve phase.

2.3.3 Root Cause Analysis

After prioritizing key failure modes from the FMEA, a “5 Whys” analysis was conducted to identify deeper root causes behind long-dwell material. This approach moved beyond surface issues by repeatedly asking “why” to trace problems back to underlying process behaviors, system limitations, and organizational incentives.

The analysis revealed recurring themes, including inventory systems focused on issuance and disposal rather than reuse, production timelines overriding material return, lack of standardized procedures for excess or partial materials, and limited cross-referencing across FSC classifications. By linking these root causes to the identified critical X’s, the team clarified why long-dwell inventory persists and established a strong foundation for targeted improvements in the Improve phase.

2.4 Improve Phase

2.4.1 Revised VSM

After analyzing the current process and identifying root causes, a revised value-stream map was developed to show how proposed improvements integrate into the workflow. Drawing on insights from SIPOC, process mapping, root cause analysis, and pilot testing, the updated map introduces earlier visibility of reusable materials via a Power BI dashboard, a defined decision point for evaluating substitutes, and a clearer engineering approval process. These changes aim to reduce delays, improve cross-referencing across FSC categories, and prevent unnecessary repurchasing.

The map also classifies steps as value-added, required non–value-added, or non–value-added to highlight inefficiencies. It shows how reusable materials can be identified earlier and how excess materials can be evaluated, returned, and re-entered into inventory instead of becoming long-dwell stock or scrap. Overall, the revised map provides a clear vision of a future-state process that improves visibility, streamlines decisions, and reduces long-dwell inventory.

2.4.2 Potential Solutions

After validating root causes in the Analyze phase, the team developed multiple targeted improvement actions rather than selecting a single solution. Each proposed intervention was directly tied to a critical issue—such as limited visibility across FSC codes, inconsistent return practices, or challenges with reissuing partial materials—to ensure solutions addressed root causes, not just symptoms.

With input from subject matter experts, controllers, and expeditors, the solutions were evaluated based on feasibility, impact, and implementation effort. This resulted in a prioritized set of actions, including a Power BI dashboard for visibility, a standardized SOP for returning partial materials, system flags for long-dwell inventory, and an engineering verification workflow to support reuse. Organizing these solutions by root cause and effort created a clear, practical roadmap for the Improve phase.

2.4.3 Evaluation Criteria

To prioritize improvement actions, a weighted scoring model was developed to evaluate solutions using structured criteria rather than subjective judgment. Criteria included operational impact, implementation effort, user adoption, material visibility, risk/compliance, and time to implement, each weighted based on importance to reducing long-dwell inventory

Each solution was then scored against these criteria, producing weighted totals for direct comparison. This approach ensured consistent evaluation across multiple dimensions, including practicality and integration into existing operations. The results showed that solutions improving material visibility and data access—especially those enabling cross-FSC identification of reusable materials—offered the best balance of impact and feasibility. Overall, this method provided a transparent, systematic basis for selecting improvements aligned with project goals.

2.4.4 Pilot Plan

After prioritizing solutions, a pilot plan was developed to test their feasibility and impact in a controlled setting. The pilot focused on the Power BI dashboard and reuse workflow, aiming to validate their ability to identify reusable materials and support decisions without disrupting operations. To keep it manageable, testing was limited to one FSC group and a single ASRS location

The pilot evaluated three areas: dashboard usability and reuse identification, the engineering approval workflow, and measurable financial/operational impact. Controllers and expeditors used the dashboard during normal requests to identify reuse candidates, while engineers determined approval for reuse. Key metrics—such as reuse candidates identified, approval rates, decision timelines, and cost avoidance—were tracked, allowing the team to assess both practicality and potential impact on reducing long-dwell inventory and costs.

2.4.5 Pilot Results

After completing the pilot, the data was analyzed to assess whether the proposed solution—primarily the Power BI dashboard—could effectively reduce long-dwell inventory. Results showed that about 48% of sampled materials had potential substitution candidates, highlighting a strong opportunity to improve reuse visibility.

However, only a small portion of these were direct replacements, reinforcing the need for engineering validation in substitution decisions. Even with this constraint, the pilot demonstrated measurable impact, identifying approximately $4,600 in avoided repurchasing costs within a limited sample.

The findings also confirmed key root causes identified earlier, including limited cross-referencing of interchangeable materials, lack of a formal substitution workflow, and insufficient system prompts for reuse. These insights guided next steps, such as refining substitution criteria, expanding the pilot, enhancing dashboard functionality, and further developing the reuse decision process.

3. Quick-Wins

In addition to long-term improvements, the project identified a quick win related to warehouse conditions in Building 6. Analysis showed that the existing seven-rack system limited organization, visibility, and had uncertain weight capacity, creating safety and efficiency concerns. Poor storage layout and environmental conditions were also contributing to material degradation and the buildup of long-dwell inventory.

These findings strengthened the case for a planned $700,000 warehouse renovation, which includes replacing the racking system and exploring environmental controls to reduce corrosion. By linking inventory issues to physical storage conditions, the project provided immediate value by supporting an ongoing infrastructure investment that improves material management and warehouse safety.

4. Results and Conclusion

The analysis and pilot testing show strong potential to reduce long-dwell inventory and improve material reuse at Tobyhanna. The pilot found that ~48–50% of sampled materials had potential substitutes, revealing significant reusable inventory that previously lacked visibility. While there were few direct replacements, many could meet requirements with engineering validation. Even within a limited sample, ~$4,600 in cost avoidance was achieved, and a second sample indicated over $50,000 in potential savings. These results demonstrate that improved visibility, structured reuse evaluation, and better cross-referencing can reduce unnecessary procurement and excess inventory.

Overall, the project indicates that long-dwell inventory is driven more by gaps in visibility, process standardization, and reuse workflows than by material shortages. Key improvements—such as enhanced data visibility, standardized return procedures, and engineering-supported reuse processes—can significantly improve material utilization. The project also added immediate value by supporting warehouse modernization efforts with data-driven justification.

The pilot results suggest the project is on track to meet its goal of reducing long-dwell inventory and cycle counts by 10% by March 2026. Consistent identification of reusable materials and demonstrated cost savings provide early validation that scaling these solutions across additional FSCs and ASRS locations can achieve—and potentially exceed—the target while improving overall operational efficiency.

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