Warehouse and Distribution Operations Improvements: A Case Study

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This paper describes how warehouse and distribution operations of a small company in Southern California were reorganized to enhance its opportunities for growth and expansion using traditional operations management techniques. By focusing on a few key areas, such as layout and workflow, quality assurance, and managing inventory levels, it was shown how this company can effectively scale up and maintain profit margins and quality of service. By reorganizing the physical space based on prioritized usage metrics (the so-called ABC analysis), and adoption of additional tools and technology the overall productivity of the warehouse were shown to increase by reduced cycle time for inbound products.

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I. INTRODUCTION

This paper is about an initiative to improve the operations of a small, but a growing company in Southern California. This company that we shall call MST, purchases and distributes electrical component parts such as switches and circuits to small and medium sized distributors. These parts are sourced from about a dozen of international and domestic suppliers and are stored and distributed from the company's headquarters and warehouses. MST has been growing rapidly in part because of its distributor-friendly ordering policies and customer service. It differentiates itself by allowing customers to purchase items in bulk or even in single units, which serves small and medium sized distributors that incur high inventory costs. High variance in customers' order quantity and frequency requires MST to carry higher inventories to maintain the desired service level. The newly launched business venture, which requires adding an extra new SKUs to the product offerings, requires further increases of inventory levels and working capital commitments. Given the current warehouse space and labor force configurations, this increase will further strain MST's warehousing operations.

MST competes in an industry with competitors that have revenues of well over $1B. MST's sales were approximately $10M in 2018 with expected annual growth

of 20% for the next few years. Being a smaller company, MST cannot rely on price to compete with the larger competitors and depends on establishing good customer relationships to expand its business. Due to price pressure, MST continuously strives to reduce its cost structure to maintain its customer base in the industry. opportunities within its business.

The project described in this paper was undertaken for MST and focused on improving warehouse and distribution operations by enlisting a team of SDSU MBA students and faculty to develop feasible solutions for its current efforts (Consulting Report, 2019).

II. PROJECT OBJECTIVES AND METHODOLOGY

MST's overall objective was to use process improvement along with capital equipment acquisition to update and streamline its operations for scalability and efficiency toward meeting its expected growth projections.

Two objectives were identified for this project:

1. Investigate warehouse and distribution operations and inventory management practices.
2. Conduct research on operational improvements and benchmarking.

For objective 1, regarding warehousing and distribution, we employed **work sampling** on warehouse personnel during visits to the company and shadowed them to capture and document existing processes while also taking measurements of the physical spaces. Our team observed the warehouse staff as they fulfilled orders noting the following:

- Item locations
- How items were picked
- Methods of counting items
- How items were packaged for shipping
- Equipment used

Using this information, process flow charts of warehouse operations and schematic layouts of the warehouse spaces were created, which included all shelving and office equipment. These layouts were used to support time and distance observations, warehouse layout improvements and examining how the inventory flows were within the warehouses.

For objective 1, regarding inventory management, sales order and inventory data from MST's ERP system were extracted into reports which provided information that included data on historical sales transactions, inventory levels over time, average cost, average price, margin, and order sizes. The data was cross-referenced with other data sources including data at customer level, transaction level, and SKU level. The SKUs were classified into three categories, "Category A-most important", "Category B: moderately important", and "Category C-least important" using the ABC analysis **based on the transaction frequency of on-hand inventory**. Data analysis was conducted using Microsoft Excel's statistical functions for creating charts and regression analysis.

For Objective 2, a combination of primary and secondary research were used to gather industry benchmarking information, industry trends, and information on warehouse equipment. The team conducted in-depth interviews with various key personnel to identify, concerns about inefficient processes, challenges and process bottlenecks, and obtaining ideas for developing opportunities for improvement. Additionally, various academic and trade journals, industry association references

such as articles from Georgia Tech's Logistics Institute, and a number of warehouse trade organizations were accessed to identify industry benchmarking data regarding warehouse management and lean supply chain operations. For warehouse equipment recommendations, industry organization websites, catalogs, and companies specializing in warehouse and inventory management were referenced. A local company that recently had implemented warehouse improvements, with a similar size operation as MST, was visited and its warehouse operations was surveyed. That survey provided a blueprint and a roadmap for the recommendation to MST's warehouse operations. The inputs from this company's employees provided valuable insight of their experiences during their warehouse upgrade.

III. KEY FINDINGS

Warehouse Space and Layout - MST operates out of two warehouses. The main warehouse is connected to its office space and storefront where approximately 20 sales and marketing employees work. This warehouse is the larger of the two warehouses at approximately 6,000 square feet and is the main area for order fulfillment and shipping, though pallets of parts are also stored there. Incoming pallets and shipments are received in this warehouse through a roll-up door that faces an alleyway in the back of the business park. This roll-up door also acts as the main pathway for outgoing shipments and for employees to access the second warehouse. The main warehouse is an "L shaped" space with ceilings of approximately 30 feet in height. The current layout of warehouse 1 and warehouse 2 can be found in Figures 6 and 7, Appendix A.

The main warehouse has nine pallet racks which are capable of each holding eight pallets of parts. These pallet racks currently house a combination of unopened pallets, piece parts, scrapped parts and empty pallets. Some parts are also stored above floor level requiring employees to use a ladder to access these parts. Accessing these parts in this manner is inefficient and also represents a potential safety issue for employees. The pallet racks in warehouse 1 are 96 inches wide with four levels of storage that are each 61 inches high. The height of these racks did not appear to be "right sized" to the height of incoming pallets leading to unused storage space. The pallet racks consist of movable shelves that can be adjusted to any height. See Figure 1 for pallet rack setup in warehouse 1. The majority of the pallet racks were inaccessible by forklift due to pallets being stored on the floors and in clutters in adjacent spaces. Figure 2 shows an example of pallets being stored on the floors in front of pallet racks that are empty and inaccessible by forklift.

The main warehouse has 61-part storage racks that house a variety of small parts available for part picking. The part storage racks are approximately 7 feet tall, 36 inches deep and are either 36 or 48 inches in width with 5-6 levels for storage. Much of these part storage racks are aligned in 3 aisles near the order fulfillment area on one side of the warehouse. Parts are accessible from both sides of the storage racks allowing warehouse staff to stock more small parts per storage rack. Figure 3 shows an example of a part storage rack in Warehouse 1.

FIGURE 1. WAREHOUSE 1 PALLET RACKS

FIGURE 2. EXAMPLE OF CLUTTER & WASTED RACK SPACE

FIGURE 3. PART STORAGE IN WAREHOUSE 1

Aisles where part storage racks are located measured 3 feet in width making it difficult for employees to maneuver and find parts. Part storage racks were all marked with location stickers which are used to stock incoming parts as well as helping to locate parts during order fulfillment. Unfortunately, during our onsite visits, many parts were incorrectly located, and warehouse employees spent a great deal of their time searching for the correct parts.

The second warehouse is located approximately 200 feet from the main warehouse. It is a rectangular shaped space with approximately 20-foot ceilings, totaling 2,500 sq ft. There is no office space connected to this warehouse and it is mainly used for storage of incoming pallets or rarely ordered parts.

Inventory Management - MST occupies a niche market in its industry. Its business model relies on offering a large and diverse selection of products and selling with no minimum order quantity (MOQ). As a result, MST lists over 10,000 SKUs for its customers ranging from rolls of electrical cables to small electrical switches. Of all these SKUs, MST holds about 1,200 in stock. The remaining SKUs are not held on hand but are ordered from suppliers when MST gets an order from a customer. Among the SKUs that are held in stock, inventory turnover varies widely.

Certain SKUs sell rapidly and are re-ordered frequently, while others have had zero sales over the past several years. The team extracted and analyzed a wide range of data points, drawn from MST's ERP system and identified a set of risks and issues that present significant opportunities to improve MST's operations.

1. Risk of selling obsolete or defective/damaged parts
2. Inefficient allocation of working capital
3. Sub-optimal placement of frequently ordered items

During on-site visits, it was apparent that many parts had been aging on the shelf with some boxes showing receiving dates more than 10 years old. These older parts are prone to quality issues, both through sheer age and through the effects of sitting on a shelf in a warehouse gathering dust, subject to temperature fluctuations and other environmental factors. Shipping defective or damaged products can impact the brand image of MST should customers receive bad quality products. Additionally, stale and excess inventory results in excessive holding costs and over-allocation of capital to inventory. As MST seeks to launch a new product line, and grows its business, it will need additional cash to fund such growth. Every dollar of excess inventory on the shelf that is not needed to support current or projected sales represents a dollar that MST will need to find via other means.

Order Frequency is a critical metric for MST's warehouse operation. It measures how often particular SKUs are ordered by customers and how often each SKU is picked, packed, and shipped. These activities are the primary drivers of warehouse operational costs. Twelve months of sales records data was analyzed to determine the Order Frequency for MST's catalog of products.

Order Fulfillment Process - As MST receives customer orders, a picking ticket is generated in the warehouse and left on the printer until an available staff collects the ticket to begin picking. After gathering the ticket, staff walks to the area where the part is located and generally collect the entire bag of parts and return to the order fulfillment table where the correct quantity of parts is counted. A scale was used, about half the time, mainly for orders with a higher quantity of parts otherwise they are hand counted. After parts were counted and packaged, the excess inventory was taken back to the respective shelf location. Warehouse employees were observed to handle order picks one-part number at a time and did not identify any other items in the nearby vicinity that were on the same picking ticket and often returned to the same area to collect another part on the ticket. Once an order was completed, it underwent a final QA check, was placed in a shipping container and the inventory system was updated. During on-site observations, product labeling was found to be small, faded, or not present on boxes to be shipped.

Parts picked from Warehouse 2 occurred at a much higher rate than originally expected. During a two-hours observation of the picking process, 10 orders were completed, and 5 trips were made to Warehouse 2. Picking tickets include parts from both warehouses and were not organized for efficient routing or purposeful trips to Warehouse 2.

A sample of a documented Order Fulfillment Process, observed during site surveys, is depicted in Figure 4.

Benchmarking - Measuring Performance - Key Performance Indicators (KPIs) of Interest:

After identification of the main process steps and sub activities of MST's warehouse and distribution operations

(Figure 5), and in considerations of both the financial and the process performance related to industry and the size, Key Performance Indicators for MST were identified.

Initially, the process steps followed within the MST warehouse were mapped out before considering any process metrics. We then considered 5 categories with 5 specific metrics within each category (see Table 1).

Taking these 5 categories into consideration in combination with our observations of MST activities, we determined that the most relevant KPIs were productivity, quality and cycle time. Following selection of the KPI categories of most interest, we then moved to determine specific measurable metrics that would reflect performance within these categories.

To determine these specific metrics, we referenced industry warehouse performance metrics which can be seen in Table 2. It is important to note that these are highly variable based on warehouse size, purpose, technology and number of locations. Referencing the research outlined above and observations of the warehouse activities, the KPI categories and measurables below were identified as most relevant to MST:

- Customer - time-related activities that impact customer receipt
- Outbound - Order fulfillment
- Inbound - Dock to stock
- Capacity/quality - inventory and order accuracy
- Employee - labor hours
- Perfect Order - 100% complete and accurate scenarios

KPI Values - Referencing the KPI's identified as being most important to MST, specific metrics were sought out that could be used for both internal and external benchmarking. Based on our research, it is recommended that MST start with a set of external benchmarking data. From there, internal benchmarking can be set to drive continuous improvement. Table 3 contains external benchmarking data, compiled by a product vendor. Metrics in Table 3 have performance categories ranging from companies that are best in class.

In addition to the metrics outlined, our research indicated that a best-in-class dock to stock time is less than 2 hours. Inventory days on hand should be based on both company's need and order forecasting, with safety stock requirements and reorder points identified.

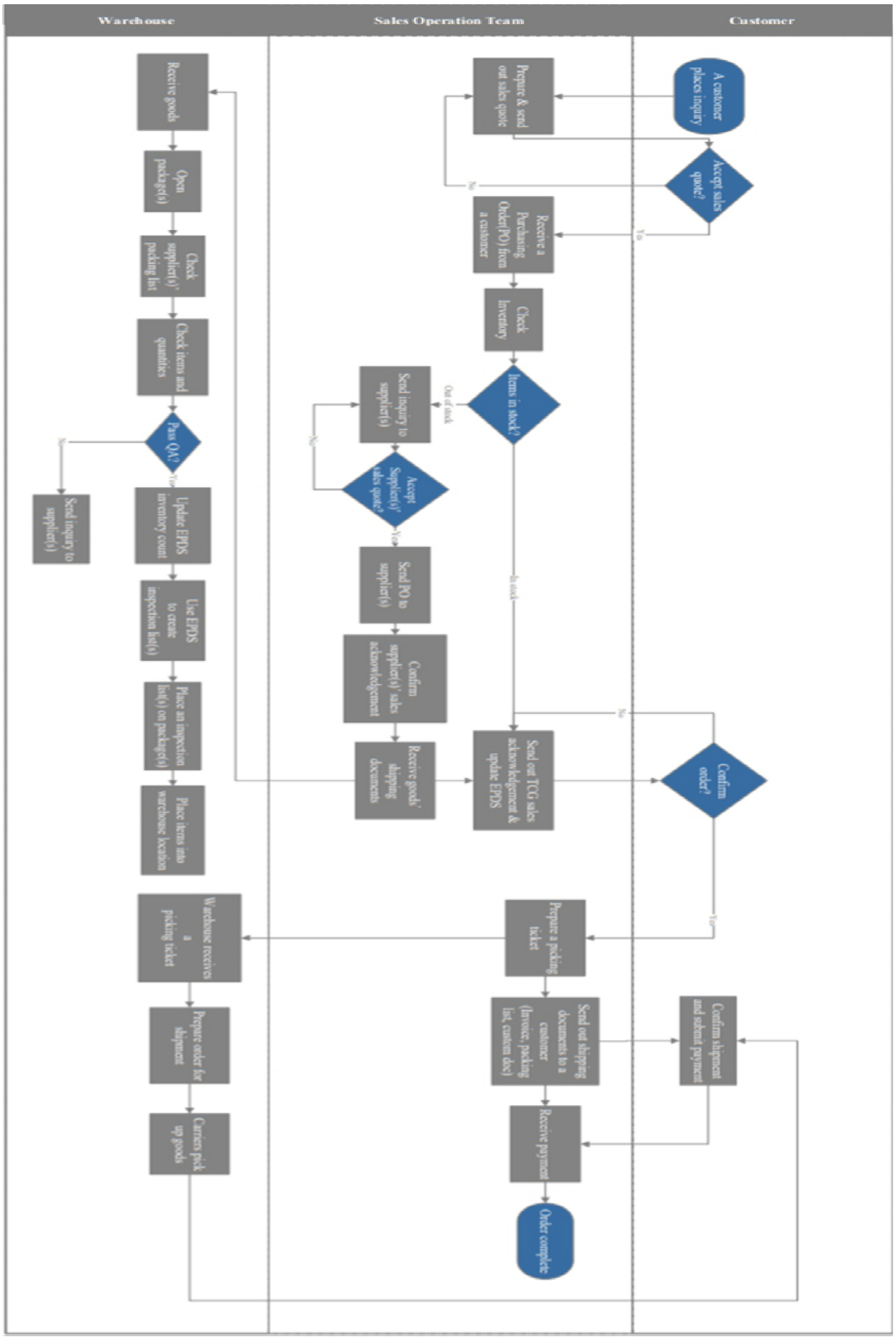

FIGURE 4 - FLOW CHART OF THE SALES OPERATIONS FULFILLMENT PROCESS

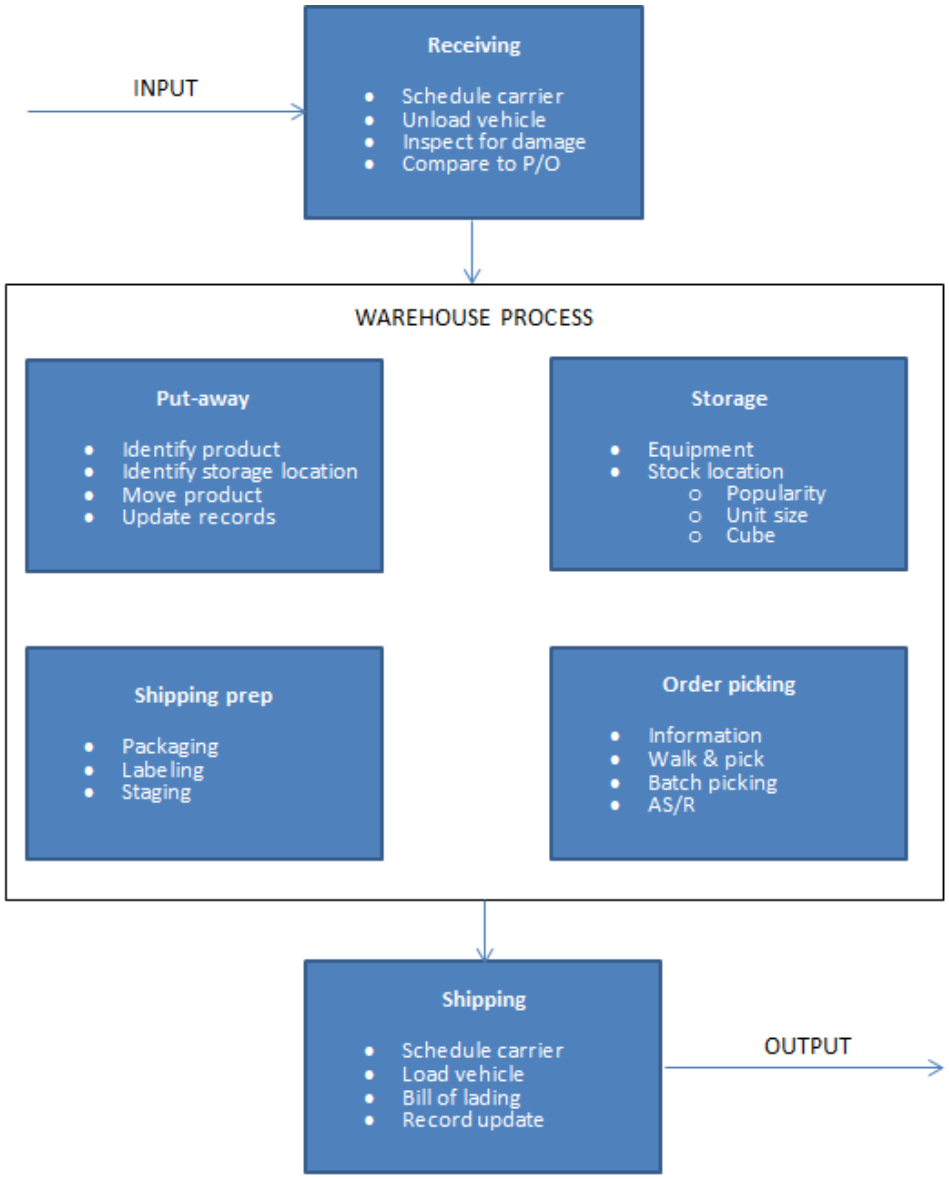

FIGURE 5: TOOL TO IDENTIFY KEY PROCESS STEPS

(Adapted from "Determining key performance indicators for warehouse performance measure - a case study in construction materials warehouse" by E. Kusrini, MATEC Web of Conferences 154.)

TABLE 1. PROCESS KPI'S

	Financial	Productivity	Utilization	Quality	Cycle Time
Receiving	Receiving cost per line	Receipts per man-hour	% Dock door utilization	% Receipts processed accurately	Receipt processing time per receipts
Putaway	Putaway cost per line	Putaway per man-hour	% Utilization of putaway labor and equipment	% Perfect putaways	Putaways cycle time (per putaway)
Storage	Storage space cost per item	Inventory per square foot	% locations and cube occupied	% Locations without inventory discrepancies	Inventory days on hand
Order picking	Picking cost per order line	Order lines picked per man-hour	% Utilization of picking labor and equipment	% Perfect picking lines	Order picking cycle time (per order)
Shipping	Shipping cost per customer order	Orders prepared for shipment per man-hour	% Utilization of shipping docks	% Perfect shipments	Warehouse order cycle time

(Adapted from "Determining key performance indicators for warehouse performance measure - a case study in construction materials warehouse" by E. Kusrini, MATEC Web of Conferences 154.)

TABLE 2. TOP 10 KPI METRICS USED FOR WAREHOUSE PROCESS IMPROVEMENTS

Top 10 metrics	2018	2017	2016
1. Average Warehouse Capacity Used	1	1	2
2. Order Picking Accuracy (percent by order)	2	2	3
3. Peak Warehouse Capacity Used	3	4	7
4. Contract Employees to Total Workforce	4	7	48*
5. On-time Shipments	5	3	1
6. Overtime Hours to Total Hours	6	6	45*
7. Part Time Workforce to Total Workforce	7	5	46*
8. Cross Trained Percentage	8	12	49*
9. Annual Workforce Turnover	9	25	20
10. Inventory Count Accuracy by Location	10	10	19

Adapted from "Warehouse and Distribution Centres: 2018 Best Practice by Campbell" (2018).

TABLE 3. PERFORMANCE METRIC VALUES FOR IDENTIFYING WAREHOUSE OPPORTUNITIES

Customer Metrics	Major Opportunity	Disadvantage	Typical	Advantage	Best-in-class	Median
On-time Shipments	Less than 94%	>= 94 and < 97.56%	>= 97.56 and < 99%	>= 99 and < 99.8%	>= 99.8%	98.20%
Total Order Cycle Time	Greater than 48 hours	>=24 and < 48	>= 9.8 and < 24	>= 3.76 and < 9.8	< 3.76 hours	16
Internal Order Cycle Time	Greater than 35.2 hours	>= 18 and < 35.2	>= 5.88 and < 18	>= 2 and < 5.88	< 2 hours	8
Outbound Metrics	**Major Opportunity**	**Disadvantage**	**Typical**	**Advantage**	**Best-in-class**	**Median**
Lines Picked and Shipped per Hour	Less than 12 per hour	>= 12 and < 26	>= 26 and < 47.6	>= 47.6 and < 92.8	>= 92.8 per hour	35
Orders Picked and Shipped per Hour	Less than 2.76 per hour	>= 2.76 and < 6.08	>= 6.08 and < 15	>= 15 and < 35	>= 35 per hour	10
On-Time Ready to Ship	Less than 94%	>= 94 and < 98%	>= 98 and < 99%	>= 99 and < 99.8%	>= 99.8%	99%
Capacity/Quality Metrics	**Major Opportunity**	**Disadvantage**	**Typical**	**Advantage**	**Best-in-class**	**Median**
Inventory Count Accuracy by Location	Less than 90%	>= 90 and < 97%	>= 97 and < 99%	>= 99 and < 99.888%	>= 99.888%	98.40%
Order Picking Accuracy (Percent by Order)	Less than 98%	>= 98 and < 99%	>= 99 and < 99.5%	>= 99.5 and < 99.9%	>= 99.9%	99.30%
Employee Metrics	**Major Opportunity**	**Disadvantage**	**Typical**	**Advantage**	**Best-in-class**	**Median**
Overtime Hours to Total Hours	Greater than 14.98%	>= 8.76 and <14.98%	>= 5 and < 8.76%	>= 2 and < 5%	< 2%	6.75%
Part-time Workforce to Total Workforce	Greater than 20%	>= 4 and < 20%	>= 0 and < 4%	>= 0 and < 0%	< 0%	1.00%
Contract Employees to Total Workforce	Greater than 30%	>= 10 and < 30%	>= 0.52 and < 10%	>= 0 and < 0.52%	< 0%	5.00%
Perfect Order Index Metrics	**Major Opportunity**	**Disadvantage**	**Typical**	**Advantage**	**Best-in-class**	**Median**
Percent of Orders with On-time Delivery	Less than 89.7%	>= 89.7 and < 94%	>= 94 and < 97.3%	>= 97.3 and < 99%	>= 99%	95.20%
Percent of Orders Shipped Complete	Less than 90.2%	>= 90.2 and < 96.5%	>= 96.5 and < 98.64%	>= 98.64 and < 99.5%	>= 99.5%	97.70%

Adapted from "Warehouse and Distribution Centres: 2018 Best Practice by Campbell" (2018).

IV. RECOMMENDATIONS

Warehouse Layout

Recommendation 1: Unclutter and scrap unneeded parts and move pallets housed on the floor to pallet racks. Clean warehouse and reprint visual indicators. This is a first step in any implementation process. Although difficult to estimate the magnitude of improvement on KPI's 1-10 of Table 2, it is expected that all would improve to some extent or other.

Recommendation 2: Modify Warehouse 1 layout and locate parts based on ABC analysis. MST was provided with three warehouse layout options for Warehouse 1 (Warehouse 2 was not a focus for this project).

Warehouse Option 1: We viewed this option as the long-term solution for MST requirements. This option requires a sizeable amount of effort to implement and utilizes a mixture of pallet racks and part storage and is laid out in such a way that each business process is separate from one another.

Warehouse Option 2: This option was an alternate layout for long term application with focus on maximizing vertical storage space. The use of vertical space is viable when growing the footprint of the warehouse may not be a possibility.

Warehouse Option 3: This option was considered a short-term solution that would allow MST to implement quickly and marginally improve operational efficiency.

All these options would impact KPI's 1-3, 10 of Table 2. KPI 1, which is average warehouse capacity utilization, is of critical impotence for MST as it is contemplating its growth strategy. Below are the specifics with respect to each option.

Warehouse 1 (Optimized Floor plan Option 1)

The most preferable alternative for MST is Option 1 optimized floor plan, which is shown in Figure 9 and contains a combination of pallet racks and part storage racks. The main advantage of this layout is the increase in storage space and ability to promote proper part flow in the warehouse which will improve the operational efficiency in the warehouse. More specifically, the benefits that MST can realize by reconfiguring Warehouse 1 are:

- Isolated areas specified for Departments allow for more lean approach to operations
- Order fulfillment aisles widened to 4+ feet wide
- 12-part racks are added for order fulfillment part storage (20% increase)
- Allow to move all order fulfillment to single warehouse and eliminate the need to house piece parts in warehouse 2
- Will promote proper process flow
- 5 pallet racks add additional storage, minimize clutter and allow for more pallet storage
- Part storage closer to fulfillment table would allow for less travel time to collect parts
    - Average distance (current): 360" (pure straight-line distance)
    - Average distance (optimized): 240"
- Receiving/storage area sized to accommodate current forklift + additional room
- Scale moved to fulfillment table
- Propose to buy additional computer for placement on fulfillment table
- More storage to corner for miscellaneous items (office, shipping, misc.)

Improving part flow and organization within the warehouse is one of the major benefits of option #1. The warehouse was configured with separate areas in mind to allow for a more focused operation. Figure 10 is our proposed layout on how the warehouse could be divided under option 1.

Figure 11is depiction of the expected process flow within the optimized warehouse. The number of process steps has been reduced.

Process Steps

1. Parts dropped off by shipping company on pallets
2. Parts on pallets moved to staging area for receiving
3. Once parts checked in, parts on pallets moved to pallet rack for storage

4. When quantity on shelf low, parts pulled off pallet rack to staging area for distribution to part storage racks
5. Parts placed on part storage racks
6. Parts picked from shelves and brought to scale and bagged to fulfill order
7. Parts moved to shipping table- final check and boxing of parts
8. Boxed order moved to final shipping area where it is picked up by shipping company

Warehouse 1 (Optimized Floor plan- Option 2)

Option 2 utilizes pallet racks to maximize storage space with the recommendation that the floor level storage area of the pallet rack be set up to house individual items for picking, see Figure 12. An example of how this would look when implement is shown in Figure 13. Another option would be to put the existing part storage racks underneath the pallet racks. This layout becomes most beneficial when it is implemented with a pull system in which pallets are stored above their picking location and pulled down to picking level when inventory gets low at the floor level picking locations.

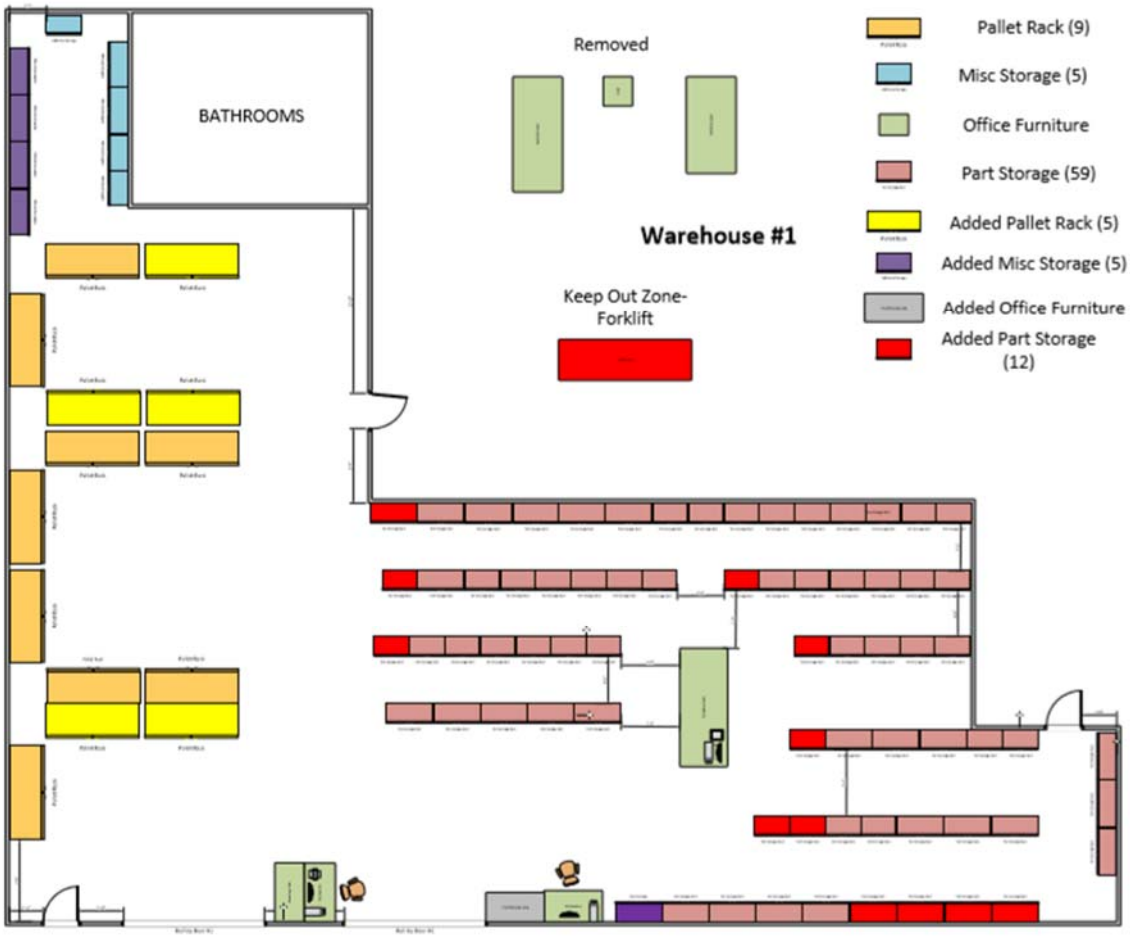

FIGURE 9. WAREHOUSE 1 LAYOUT - OPTION 1

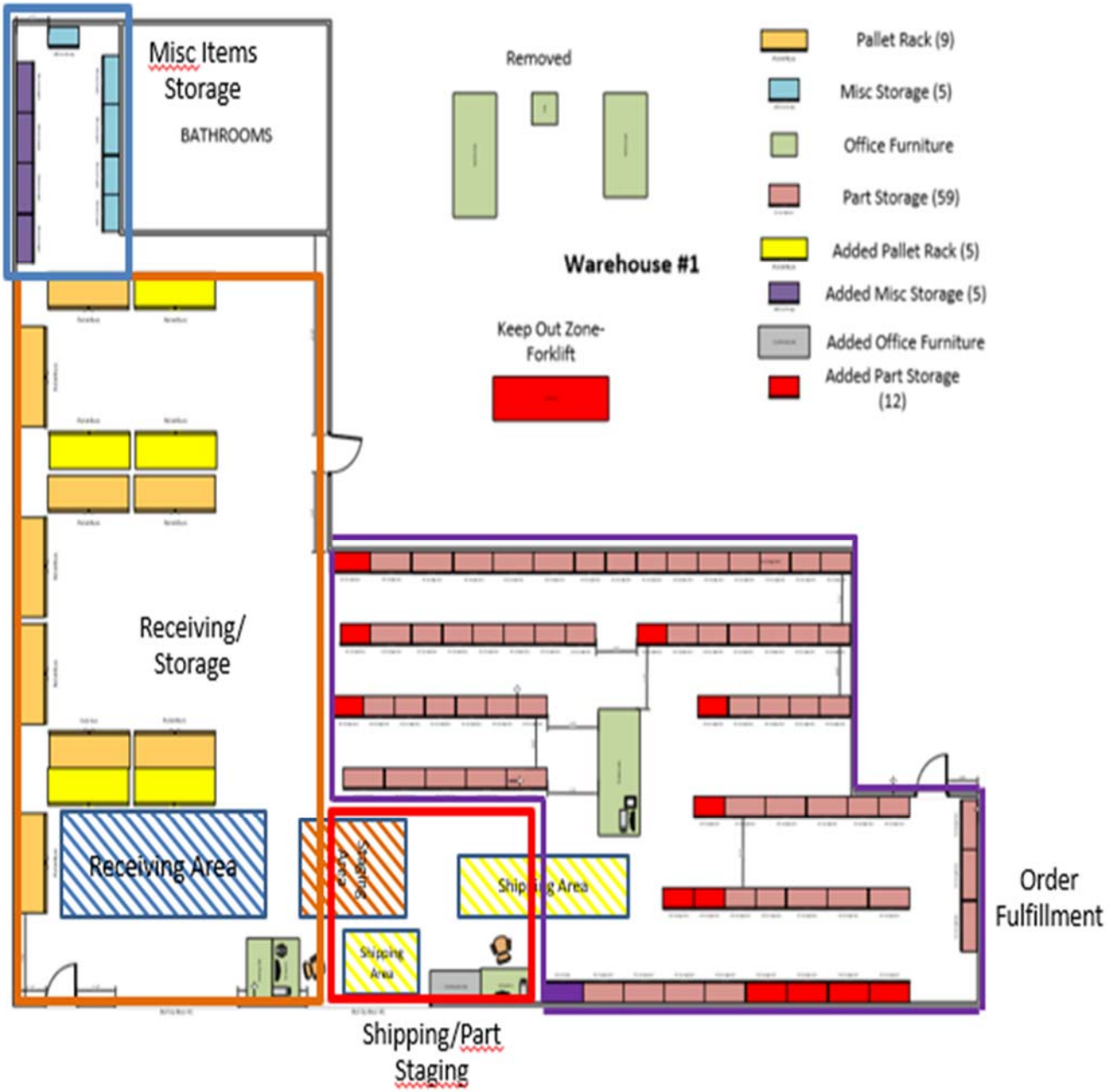

FIGURE 10. WAREHOUSE 1 LAYOUT OPTION 1 - DISCIPLINE LOCATIONS

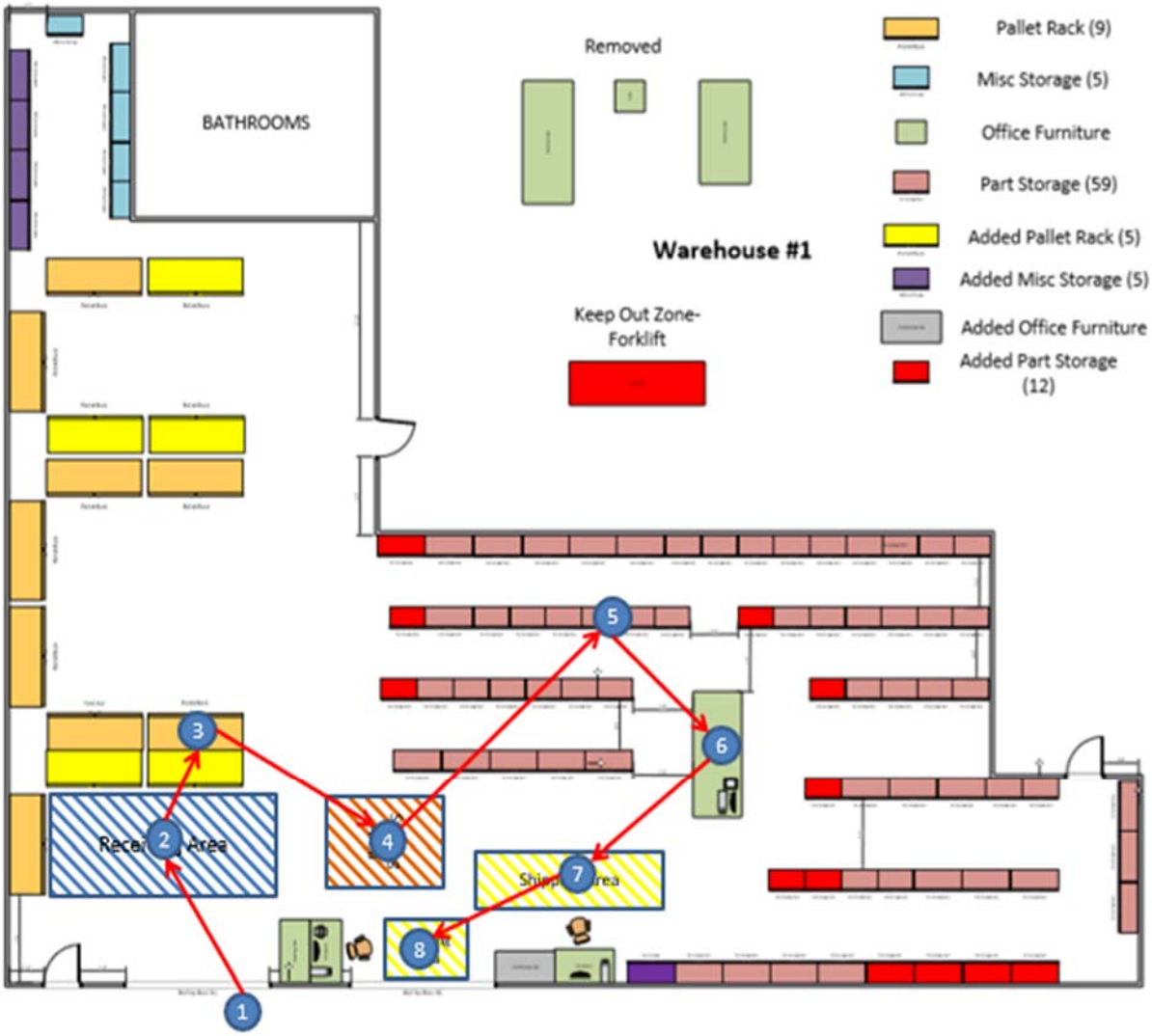

FIGURE 11. PROPOSED PART FLOW WITHIN WAREHOUSE 1 - OPTION 1

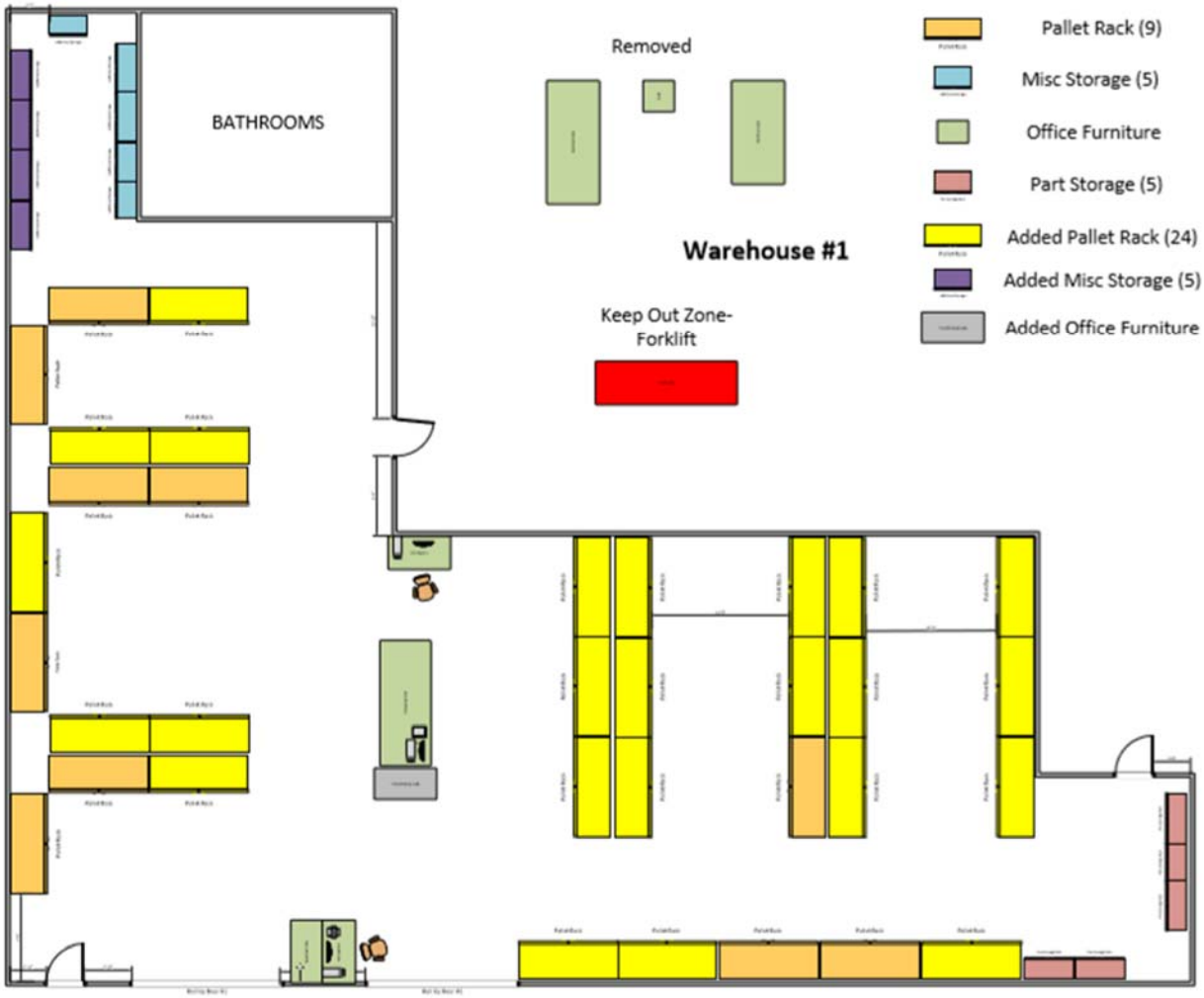

FIGURE 12. WAREHOUSE 1 FLOOR LAYOUT - OPTION 2

FIGURE 13. LOWER LEVEL PALLET RACK SETUP FOR LAYOUT OPTION 2

Warehouse 1 (Optimized Floor plan - Option 3)

The first two options require significant amount of time and labor input to implement which may not immediately work with MST's schedule. As a result, we suggested a third proposal that required less labor and time to implement and should improve the warehouse layout (See Figure 14). While the results may not be earth shattering, this layout will facilitate better process flows and drive a more efficient picking procedure, especially if some of the other recommendations above are followed. Within this layout, aisles in the picking area have been widened, unused furniture was removed, and the part fulfillment table would be placed in the center of the part fulfillment area to improve proximity to parts. This layout could likely be configured during a weekend so that normal business operations are not impacted. This layout is similar to the ideal layout (option #1) and could be handled in a phased approach.

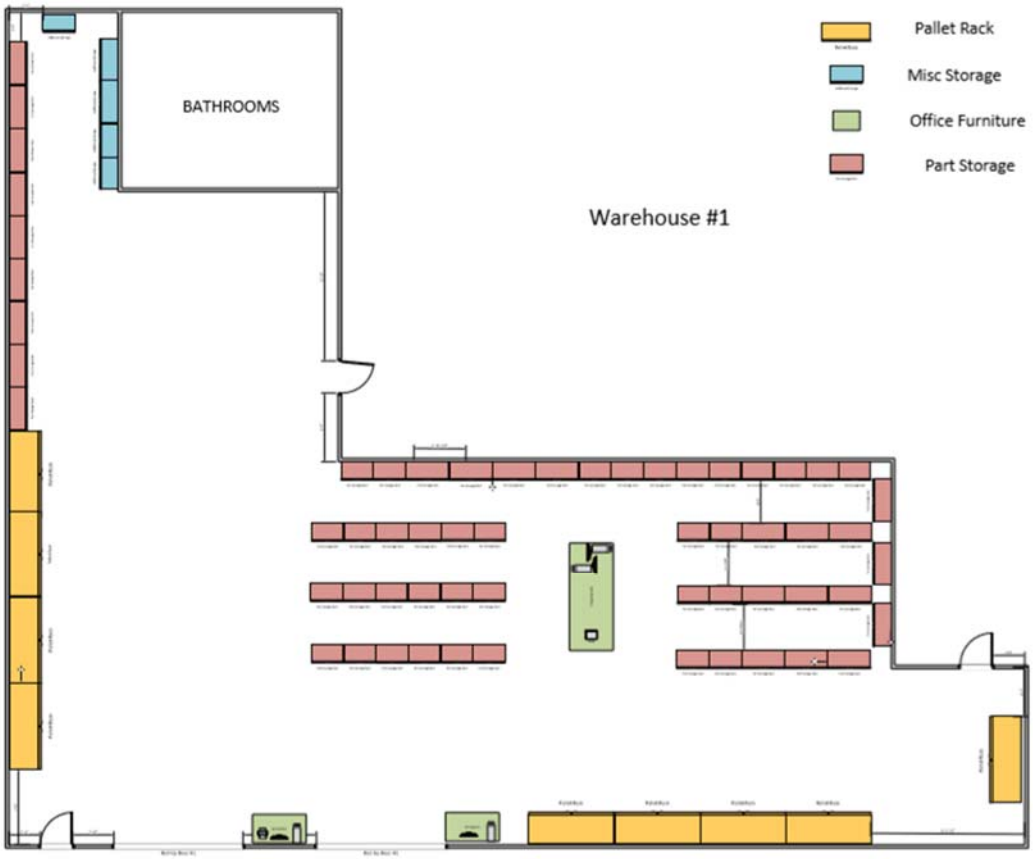

FIGURE 14. WAREHOUSE 1 LAYOUT - OPTION 3

Following implementation of the new floor warehouse, inventory would be located to appropriate storage locations based on ABC analysis. "A level" parts should be located in storage racks closest to the order fulfillment table while "C level" parts should be located further away. This should improve overall efficiency of the order fulfillment process. It was anticipated that there would be some cost savings (~ 5%), even though it would be rather challenging to quantify the amount as the value of these layout improvements also are impacted due to changing demand patterns.

Recommendation 3: Implement quarterly reviews of the warehouse layout with management and employees to continuously improve. Due to changing demand pattern, which would impact KPI's 4, 6, 9 and 10, it necessary to evaluate the location and flow of new products and parts within the warehouse and the fulfillment operation.

Processes

Recommendation 1: Establish a set of metrics (e.g., cycle time, on-time shipment) to track performance and hold weekly meetings with management and employees to review operations.

Recommendation 2: Automate label printing process. Automating printing process would improve overall efficiency and reduce the chance of errors. By automating this process, it is estimated that MST could save approximately 1.5 hours per 1,000-part numbers processed.

Recommendation 3: Minimize usage of Warehouse 2 by relocating as much inventory as possible to Warehouse 1. The orders for remain products and parts in Warehouse 2 would benefit by being combined and picked as a single batch. This would improve the KPI 2 on Table 2 for Warehouse 2.

ERP and Inventory Control System

Recommendation 1: *Reduce excess inventory.* Data drawn from the ERP system show significant quantity and dollar value of on-hand inventory for items with very small quantities sold over the prior 12-month period, including parts with zero sales in that timeframe. The data focused on the top 125 items by dollar value as they it represented about the 50% of the dollar value of all on-hand inventory. Based on Average Daily Sales for each of these items, it was determined that many parts had Days Sales on Hand values in excess of 2 years. We recommend pruning this inventory through a combination of discounted sales and scrapping. Cash recovered through sales or scrap (via tax write off) of such item then could be used to fund inventory expansion for products with greater turnover or used to fund technology and tool improvements.

Recommendation #2: Implement a reorder point system for high volume SKUs. Reorder point systems specify a quantity of inventory on hand that triggers a restocking order. The quantity that triggers reorder and the amount to be ordered are determined for each SKU and these values are based on the lead time for each part and the sales history for each part. MST's current no minimum order quantity policy and its legacy approach to reordering has had the effect over time of inflating value of inventory on hand and depressing inventory turnover. This recommendation was aimed to redress this situation and making the inventory leaner and less costly.

Through the use of basic operations tools and techniques we were able to provide a tangible roadmap guide the future warehousing and fulfillment activities of this firm. We hope to be able to follow up

in the future and report on its evolution as it ramps up for its growth.

V. ACKNOWLEDGMENT

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APPENDIX A: WAREHOUSE FLOOR LAYOUT

Figures 6 and 7 depict current layouts of the two MST warehouses created using Microsoft Visio.

FIGURE 6. CURRENT WAREHOUSE 1 LAYOUT

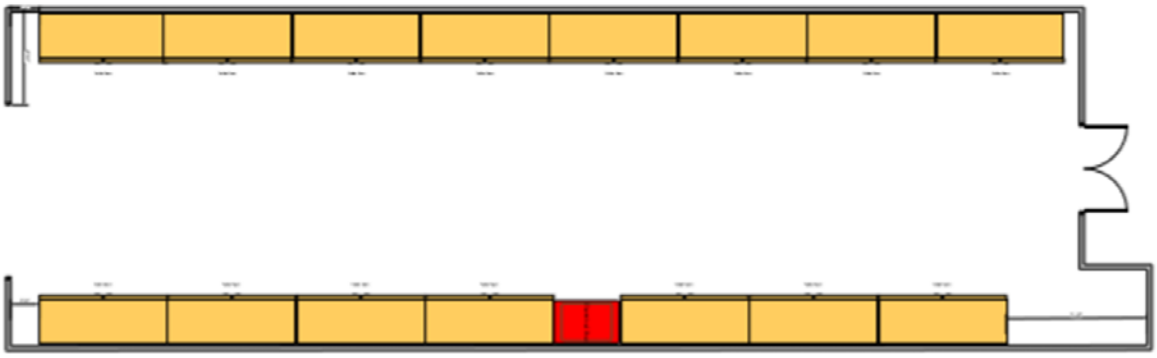

FIGURE 7. CURRENT WAREHOUSE 2 LAYOUT

Item process flows in relation with warehouse space were also documented to identify opportunities in MST's operation. See Figure 8 for documented current state process flow within MST's warehouse 1. Individual process steps corresponding to each process number are documented below the layout.

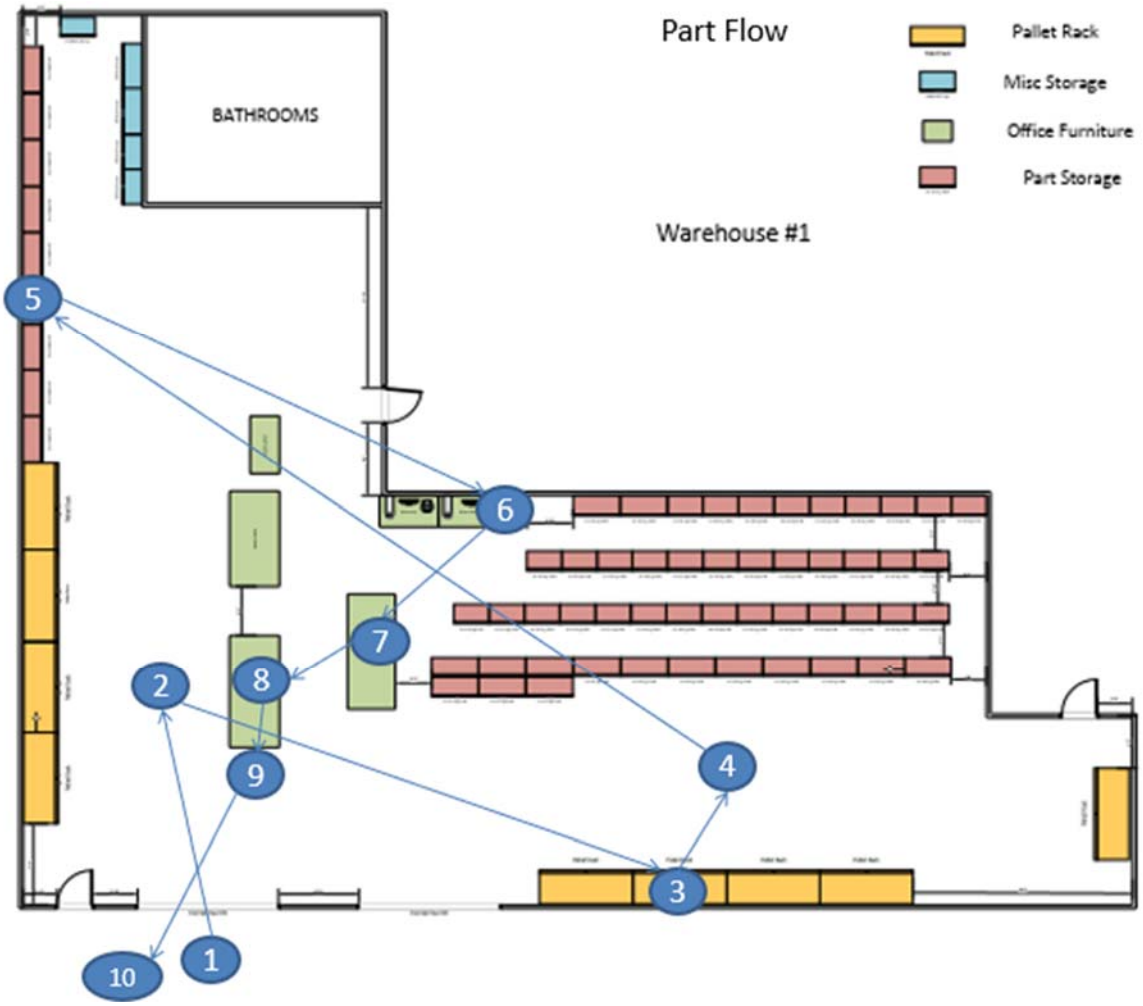

FIGURE 8. CURRENT FLOW OF PARTS WITHIN WAREHOUSE 1

Process Steps:

1. Parts dropped off by shipping company on pallets
2. Parts on pallets moved to staging area for receiving
3. Once parts checked in, parts on pallets moved to pallet rack (or floor) for storage
4. When quantity on shelf low, parts pulled off pallet rack to staging area for distribution to part storage racks
5. Parts placed on part storage racks
6. Parts picked from shelves and brought to scale to measure quantity
7. Parts bagged at fulfillment table
8. Parts moved to shipping table- final check and boxing of parts
9. Boxed order moved to final shipping area
10. Parts picked up by shipping company

APPENDIX B: TIME & DISTANCE OBSERVATIONS

During on-site visits the following data were gathered by shadowing warehouse employees during the order fulfillment process. We observed 10 orders being fulfilled during a 3-hours of observations. Table 4 provides the summary of those observations which includes the total distance travelled and time to complete each activity.

TABLE 4. SUMMARY OF TIME AND DISTANCE OBSERVATIONS

	Time & Distance Observations				
	Operation	Task	Distance Travelled (ft)	Time of Operation	Comments
Order #1	A	Find item on shop floor	51	8:00	Pallet ladder in the way of most direct path, large order (40,000 parts), spent a lot of time looking for PN, may want to add total
	B	Get rolling cart	69		
	C	Take cart to item	69		
	D	Load parts & move to pallet	67		
	E	Take cart to item	67		
	F	Load parts & move to pallet	67		
	G	Take cart to item	67		
	H	Load parts & move to pallet	67		
	I	Take cart to item	67		
	J	Load parts & move to pallet	67		
	K	Repack pallets	0	0:45	
	L	Move pallets to shipping area	15	0:47	
	M	Add warning labels to each package	60	0:48	2 extra trips to table for labels
	N	Shipping, Info Labels	60	1:40	
		Total	793	12:00	

Order #2	A	Walk to warehouse 2	207	1:00	
	B	Looking for parts in warehouse 2	53	3:28	Opened and looked at part, spent nearly 2 minutes looking for box
	C	Walk back to warehouse 1	244	0:47	
	D	Check qty of parts	0	0:30	
	E	Package parts	0	0:25	
	F	Total	504	6:10	
Order #3	A	Locate item	10	0:34	Low quantity order, a lot of PN's
	B	Take to prep table	6	0:56	
	C	Take to scale and count	13		
	D	Return to prep table	13		
	E	Return item to stock	6	0:15	
	F	Print label & apply to order	18		Label is typed in for each part- should be automated
	G	New order (steps B-F)	56	0:54	A lot of back and forth- spends 0:05 sec printing labels for each part
	H	New order (steps B-F)	56	0:54	
	I	New order (steps B-F)	56	0:48	
	J	New order (steps B-F)	56	1:03	
	K	New order (steps B-F)	56	0:54	
		Total	346	6:18	
Order #4	A	Walk to warehouse 2	215	0:32	
	B	Pick item	0	0:50	
	C	Walk to warehouse 1	215	0:34	
	D	Add stickers to bag	0	0:25	
		Total	430	2:21	
Order #5	A	Look for part & walk to scale	115	4:30	Parts not in location- need better organiztion
	B	Scale- count 10 to calibrate	0	0:20	Need to look into more efficient weighing process
	C	Add parts to scale to get correct qty	0	0:37	
	D	Bag	0	0:43	
	E	Print label & apply to order	2	0:45	
	G	Rebag stock & put in correct location	20	0:23	
		Total	137	7:18	Single PN

Order #6: Shipping	A	QA of shipping order	30	0:24	Once back to other table
	B	Box shipping order	0	0:53	
	C	Manifest & ship label	60	2:27	Manifest and shipping performed at desk- some back and forth
		Total	90	3:44	
Order #7	A	Walk to warehouse 2 + Locate part	311	2:27	Spend a lot of time looking for part- parts don't seem to be in right place
	B	Walk to warehouse 1	165	0:35	
	C	Print label and packaging	10	0:23	
		Total	486	3:25	
Order #8	A	Looking and confirming part	66	1:33	One box ordered (larger qty)
	B	Check qty and reseal box	0	1:03	
		Total	66	2:36	
Order #9	A	Find and pick part	135	1:30	
	B	Print label and package	10	1:55	
	C	Finalize order	0	0:23	
		Total	145	3:48	
Order #10	A	Walk to warehouse 2 & pick part	548	3:03	Walked to warehouse 2 twice
	B	Pick second part	26	0:20	
	C	Walk to warehouse 1	165	0:38	
	D	Place loose items in individual boxes & print/apply labels	20	2:19	Loose items had to be packaged- may want supplier to do this?
		Total	759	6:20	