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# Inspection Process Flow Development for a Warehouse

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Inspection Process Flow Development For A Warehouse

By

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This thesis has been examined and approved by the following members of the student's committee.

Kuldeep Agarwal, Advisor

Harry Petersen, Committee Member

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# Abstract

The project is based on a medical device outsourcing company in the US. In 2018 the company added a 44,000 sq ft new warehouse. With the scales of growth and market competition, it has come to a need to optimize production capacity to achieve 98% monthly on time delivery target. Optimizing production capacity comes with efficiently managing operations that impact overall product lead time. A primary factor that impacts the overall product lead time is production preparation time. Production preparation time is impacted by lead times of 3 operations managed by the new warehouse - Receiving Inspection, Incoming Inspection, and Material Packing Operation. In fact, material packing operation is impacted by lead times of receiving and incoming inspections, since material packing does not even start for a part number until its receiving and incoming inspections are completed and parts are transferred into a warehouse storage bin. Therefore, it is critical to efficiently manage product lead time from receiving inspection to bin storage to achieve 98% monthly on time delivery target. There are no current company projects that focus primarily on the product lead time from receiving parts to bin storage. As a result a project was defined and carried out to evaluate per lot total lead time from receiving parts to bin storage in the new warehouse. Current process flow from receiving inspection to bin storage was traced, a process flow was developed, cycle times of all process steps were recorded and a current value stream was developed. Based on current value stream total lead time of 12.5 hrs, a goal for total lead time per lot was set at 60 minutes or less. For current value stream map analysis lean based and quality-based metrics were defined, and kaizen bursts activities were identified in regard to lean and quality metrics. Kaizen burst activities were used to craft improvement opportunities, where they were incorporated into a new process map called, future value stream map. Future value stream map was developed with predicted cycle times on identified improvement opportunities and it was analyzed with respect to lean and quality metrics. Upon analysis, future value stream map was predicted to reduce labor cost by $5.72 per lot. This predicted annual savings of $228,890. Labor cost savings were primarily contributed by

value added and non-value added work load reduction of receiving clerks followed by that of Quality Inspectors. Total lead time was predicted to be at 739.6 minutes, 10.7 minutes reduced per lot from current process. Total lead time without supplier or quality waiting times (effective working time) per lot was predicted to be 58.6 minutes, which met the target lead time of 60 minutes or less. That was a 5.7 minute time reduction per lot inspection from the internal (company) current process itself without any regard to external (supplier or quality) waiting times. 90% of total lead time included supplier waiting time. Therefore, total lead time in the future value stream map could be further improved if supplier waiting times were significantly reduced which would lead into achieving total lead time target of 60 minutes or less.

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# Introduction

## Summary

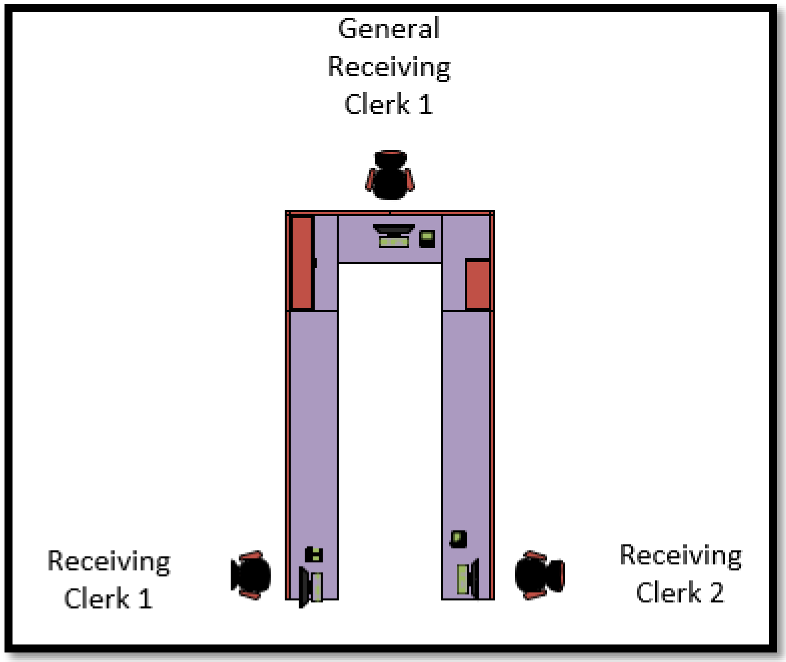
98% monthly on time delivery target was established. As a result, a project was defined and carried out to evaluate the overall lot lead time from receiving parts to bin storage in the new warehouse. Current process flow from receiving inspection to bin storage was traced, a process flow was developed, and cycle times of all process steps were recorded. Based on current value stream map total lead time of 12.5 hrs a goal for total lead time was set at 60 minutes or less per lot. Kaizen bursts activities were identified in regard to pre-defined lean and quality metrics. Kaizen burst activities were used to craft improvement opportunities, where they were incorporated into a new process map called, future value stream map. Future value stream map was analyzed with respect to lean and quality metrics. Upon analysis, future value stream map was shown to bring the total lead time to 12.3 hrs which included 58.6 minutes of lead time without supplier or quality waiting times, and a $6 labor cost reduction per lot, resulting an annual labor cost savings estimate of $228,890 in the warehouse inspection processes. Supplier lead time included 90% of 12.3 hrs of future value stream lead time. Thus, future value stream map would have met the target lead time of 60 minutes per lot, if supplier waiting times were cut down significantly.

## Background Information

98% monthly on time delivery target was established. So the company needed to evaluate the total lead time from receiving parts to bin storage in the new warehouse. The warehouse has 44,000 sq. ft and is mainly to run 3 operations: Receiving inspection, Incoming inspection, and Material packing operation. In addition to its primary operations, incoming and WIP materials storage are also being performed. There are 10 personnel employed in 8 operational areas of the warehouse, which include loading docks, receiving inspection U-shaped cell, receiving staging area, incoming inspection suite, incoming staging area (also called TX area), production returns staging area, incoming and WIP material storage, and material packing area. Warehouse operates one shift from Monday through Friday for 8 hrs. On average, 40,000 lot numbers or 29,800-part numbers are processed through the warehouse loading docks, annually. Receiving inspection serves several purposes.

1. Receiving products from loading docks
2. Identifying products received in with a company label
3. Staging parts for incoming inspection
4. Maintaining traceability in Enterprise Resource Planning (ERP) from receiving end
5. Performing receiving inspection per company procedures
6. Verifying receiving inspection
7. Transferring receiving accepted parts to warehouse bins

Receiving team includes 3 receiving clerks. Two Receiving Clerks (Clerk 1 and Clerk 2) are assigned to 1 through 5 tasks above and a General Receiving Clerk (Clerk 3) is assigned to 5 through 7 tasks. All 3 receiving clerks work in a U-shaped cell below. Receiving team manages the loading docks, receiving inspection, receiving staging area, and parts storage into bins. Around loading docks, received parts are staged for receiving inspection. A WIP parts on hold shelf is placed by Receiving Clerk 1. Receiving clerks move the parts to General Receiving clerk via a conveyor belt. Orders are inspected per lot number. One or many lot numbers can be present in one packing slip, a supplier document that gives supplier name and contact information, purchase order number, supplier part number, lot number, and quantity etc. Packing slip is transferred from receiving team to incoming team to bin storage. Receiving accepted parts are stored in receiving staging area. Rejected parts are set to a side of the cell.




Incoming team has two Quality Inspectors assigned to incoming inspection suite. Inspection suite is divided to two spaces to include a clean room and a controlled environment room. Incoming staging area (TX) is used to store incoming accepted parts, and incoming rejected parts are stored in the inspection suite. Inspection suite also has a WIP parts on hold shelf.

Inspection completed and accepted parts are stored in warehouse bins until they are used up for material packing operation.

Fourteen indirect office personnel are also involved with receiving and incoming operations, mainly, company two Buyers, three Quality personnel, and nine Customer Service (CS) personnel.

## Definition of Present Study

98% monthly on time delivery was established. So, company needed to evaluate the total lead time from receiving parts to bin storage in the new warehouse. The present study was initiated in an attempt to develop an efficient inspection process in the warehouse so that company meets 98% monthly on time delivery. The scope of this study is limited to receiving inspection, incoming inspection, and parts moving into bin storage. Incoming and WIP materials storage, production returns staging, and material packing operations are out of scope for this study. Warehouse areas that will be impacted by this study are loading docks, receiving inspection cell, receiving staging area, incoming inspection suite, incoming staging area (TX area). In terms of warehouse personnel, 2 Receiving Clerks, a General Receiving Clerk, and 2 Quality Inspectors would be involved in this study.

# Methodology

## Test Protocol

A two-part methodology was defined to develop a current value stream map. In the first phase, processes from receiving to receiving staging to incoming to incoming staging to bin storage were mapped to create a process flow chart. Processes were traced from its end to its beginning. Value and non-value-added were defined for steps involved in the processes. Value-added Steps included functions that customers had paid for and Non-value-added steps encompassed functions that customer had not paid for but was mandatory for operation [1].

Value-added and non-value-added step was identified as an “Operation” on the process flow chart per definitions. Steps neither value nor non-value added were categorized into four lean wastes – Transport, Inspect, Delay, and Storage.

| **Process Step Category** | **Definition per study** |
|---|---|
| Operation | Value or non-value-added process step |
| Transport | Transporting product between processes |
| Inspect | Visual and dimensional inspections or verifications |
| Delay | Whenever goods are not moving or being processed, the waste of waiting occurs |
| Storage | Work in process parts, excess inventory |

Cycle times were recorded for all functional steps in the process flow chart. Cycle time included working time and waiting time. Each step cycle time was averaged with at least 2 recorded cycle times. In the second phase, process flow chart was used to create the current value stream map tracing the process flow with lean symbols. Cycle times were put in place with their corresponding steps in the current value stream map and the current value stream was completed.

Next, product lead time related quality and lean metrics were defined to identify kaizen burst activities in the current value stream map [2].

| **Lean Metric** | **Quality Metric** |
|---|---|
| *Average labor cost of one process occurrence* (Total labor of all annual process occurrences) | *Process Errors* |
| *Total Cycle time* (Value Added Time, Non-value-added time, Takt Time, Process Cycle Efficiency, Process Value) | *Part Identification* |
| *Effective working Time (Total cycle time without waiting times)* | *Part Traceability* |
| | *Visual Controls* |

Current value stream was analyzed to highlight functional steps that had a significant effect on the product lead time related lean and quality metrics. Accordingly, kaizen burst activity identification started with consideration to lean and quality metrics. Once kaizen burst activities or improvement opportunities were identified, solutions were proposed. Solutions were incorporated with estimated cycle times if applicable, into a new process map, called Future value stream map. Finally, future value stream map was also analyzed with respect to lean and quality metrics and was shown how lean and quality based solutions contributed to reducing overall product lead time from receiving to bin storage.

# Results

## Process Flow Chart

Process
Flowchart.docx

## Current Value Stream Map

The current value steam map starts at the warehouse receiving dock. Receiving clerk opens the hot list in the drive and selects a part number in priority. Clerk contacts company buyer to obtain the tracking # and carrier # pertaining to the part number. Using the tracking # and carrier #, Clerk checks if the part # has been delivered to the warehouse. If the part # is delivered, the desired part # included package is picked up from the package delivered area. If the part is not delivered, any package from the package delivered area is picked up. If there are no parts included in the hot list for that day, clerk picks up any package from the package waiting area as well. A package includes one lot # of the part number.

Picked up package is moved to the U-shaped receiving team work cell. The packing slip is taken out of the package. Packing slip shall include the supplier name, supplier contact information, purchase order number, supplier part number, lot number and the quantity. Using the part number, the corresponding part drawing is searched in Document Management System (DMS) and receiving inspection requirements are determined from the part drawing.

If receiving inspection requirements include a Certificate of Conformance (CoC) check, clerk checks if such CoC exists with the packing slip or inside the package.  When CoC does not exist, clerk emails buyer or Customer Service (CS), places the lot on WIP on-hold shelf, and waits for CoC paperwork. When paperwork is received, clerk proceeds to the next step, as well as if no CoC is required per requirements.

Clerk records the lot # information in Enterprise Resource Planning (ERP), prints out the company label with supplier name, part name, part number, lot number, quantity, and part code (A, B, C etc.) along with a serial code. Clerk verifies company label information against the packing slip and also what was entered into ERP. If the lot is accepted clerk proceeds. If the lot is rejected, the rejected package will be moved to a side and Quality is contacted to create a NCMR for the rejected lot.

Part drawing is checked again to identify the need for incoming inspection. If incoming inspection is needed by the part drawing, clerk walks towards receiving staging area and places the package on the Quality Inspector waiting shelf or in the receiving staging area. If not needed, the package is transferred to the general receiving clerk via a conveyor belt. In both cases, packing slip is placed either inside the box or on the box.

If incoming inspection is not needed per the drawing, General Receiving clerk receives the package, verifies the company label against the packing slip. From the packing slip, general receiving clerk determines the general receiving inspection type - whether it is 000 or AA(X). If 000, clerk inspects for shipping box damage(s) as well as for contamination. If AA(X), clerk finds the inspection procedure and part drawing in DMS and prints out the drawing. Clerk unseals the box, takes samples from the package per the inspection criteria, and performs AA(X) inspection. If the lot is accepted per 000 or AA(X) procedure, a green sticker is placed on the package, the general receiving approved seal is stamped on the packing slip, the package is placed in a warehouse bin, and the transaction is recorded in ERP. If the lot is rejected, the rejected package will be moved to a side and Quality is contacted to create a NCMR for the rejected lot.

If incoming inspection is needed per the drawing, Quality Inspector prints off the First In First Out (FIFO) list from ERP, writes down the part number and lot number on a sticky note, and walks towards the Quality Inspector waiting shelf to find the package by part number and lot number. If the package is not in the Quality Inspector waiting shelf, then Quality Inspector goes around the receiving staging area looking for the desired package. Quality Inspector finds the package and takes it back to the inspection suite. Quality Inspector finds the packing slip inside or on the box and verifies the company label against the packing slip. Quality Inspector finds the relevant incoming procedure and the part drawing by entering the part number in DMS. Company packing slip # is written down on packing slip and supplier paperwork if any. Lot # and quantity on the packing slip are verified against the ERP and drawing # and Rev # are written on the packing slip.

If the supplier CoC verification is required per incoming inspection requirements, supplier CoC information is verified. If CoC is incomplete, Quality Inspector emails buyer or CS and waits for complete CoC paperwork from supplier. When Supplier CoC is received in or while waiting for CoC or when supplier CoC verification is not required per procedure, Quality Inspector proceeds to the next step.

Quality Inspector determines the sample size from the inspection procedure. If sample size is greater than 3, Quality Inspector finds the pertaining inspection sheet in the drive and verifies the inspection sheet information against the drawing. If Quality Inspector does not find the inspection sheet in the drive, then the part number of the lot is identified as a new part number accordingly, a new inspection sheet is created for that part number in the drive. New inspection sheet is sent to Quality for verification and approval and the package is put on hold. Quality notifies the Quality Inspector by email the sheet has been approved. Quality Inspector finds the approved inspection sheet in the drive and verifies information against the part drawing before starting the inspection. However, if the sample size is less than 3, Quality Inspector prints the drawing and proceeds.

Quality Inspector sets up the measuring device and takes parts per required sample size out of the package in random. Quality Inspector inspects the parts per procedure. Once done, Quality Inspector double bags parts, places parts back in the package, and seals the box. If the lot is accepted, Quality

Inspector proceeds to the next step. If the lot is rejected, Quality is contacted to create a NCMR, and rejected lot will be left to a side in the room.

Accepted package is labeled with a green sticker. Quality Inspector signs and dates the part drawing and prints off the inspection sheet if any. Incoming inspection information is entered into ERP and Quality Inspector approved seal is stamped on the packing slip. Quality Inspector makes sure packing slip, CoC (if applicable), drawing (if applicable), inspection sheet (if applicable) are accurate and complete and then scans them into the drive. Scanned pages are checked for the scanned order and paperwork is dropped off in the Doc Control folder in the inspection suite. Quality Inspector moves the accepted package to the TX area. General Receiving clerk identifies a package waiting at the TX area, picks up the package, places it in a warehouse bin, and records the transaction in ERP.

Current VSM.vsdx

# Discussion

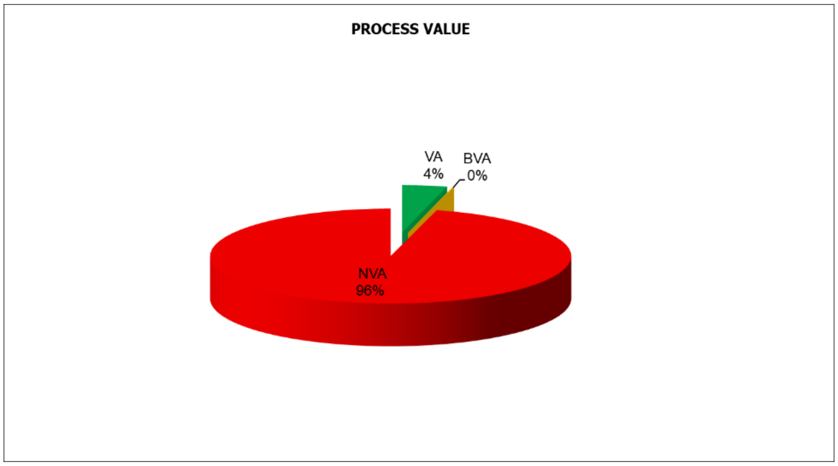
## Current Value Stream Map Analysis

Defined lean metrics were calculated for the current value stream map from receiving to bin storage.

| PROCESS VSM SUMMARY | | | | |
|---|---|---|---|---|
| **Number of Annual Customer demands processed (Parts/Transactions/Files)** | 40,000 | | | |
| **Average labour cost of one process occurrence** | $58.87 | | | |
| **Total labour cost of all annual process occurrences** | $2,354,723 | | 21.2 | FTEs |
| **Times for One Process Occurrence** | **seconds** | **minutes** | **hours** | **days** |
| **Total Cycle time (Calendar time)** | 45,019 | 750.3 | 12.51 | 0.52 |
| **Effective Working Time (W/T)** | 3,859 | 64.3 | 1.07 | 0.04 |
| **Value Added Time (VA/T)** | 1,804 | 30.1 | 0.50 | 0.02 |
| **Business VALUE Added Time (BVA/T)** | 50 | 0.8 | 0.01 | 0.00 |
| **Non Value Added Time (NVA/T)** | 43,165 | 719.4 | 11.99 | 0.50 |
| **TAKT Time (transaction frequency)** | 182 | 3.0 | 0.1 | 0.00 |
| **PCE (Process Cycle Efficiency)** | 4.01% | | | |
| **Average Standard Work in Progress (WIP)** | 247 | **parts/files/transactions** | | |

Current value stream operated with an average labor cost of $59 per lot inspection (of one process occurrence). Annual labor cost of the entire operation totaled to $2,354,723. Overall product lead time per lot inspection was 750 minutes, value added time only accounted for 30 minutes off total lead time. Effective working time per lot inspection was 64 minutes. Process Cycle Efficiency was calculated at 4%, given 3 minutes of takt time per lot inspection.

Value added time, business value added time, and non-value-added time were analyzed to assess the process value.




Current inspection process is 96% non-value added, 4% value added, and almost zero business value added. Over 90% non-value added is very common in manufacturing, however it may be worthwhile to find improvement opportunities to reduce non-value added % and increase value added % in the process value.

Annual workload was analyzed to determine operator functions that had highest and lowest annual workloads in the process, so that improvement opportunities that had significant effect on lead time could be identified accordingly.

| WORK LOAD | | | |
|---|---|---|---|
| **Operator Function(s)** | **One process occurrence (seconds)** | **All annual process occurrences (hours)** | **FTEs (Full Time Employees)** |
| Receiving Clerk | 2,254 | 25,043 | 12.4 |
| General Receiving Clerk | 1,233 | 13,699 | 6.8 |
| Quality Inspector | 327 | 3,638 | 1.8 |
| Buyer/ Quality / CS | 45 | 497 | 0.2 |
| | | | |
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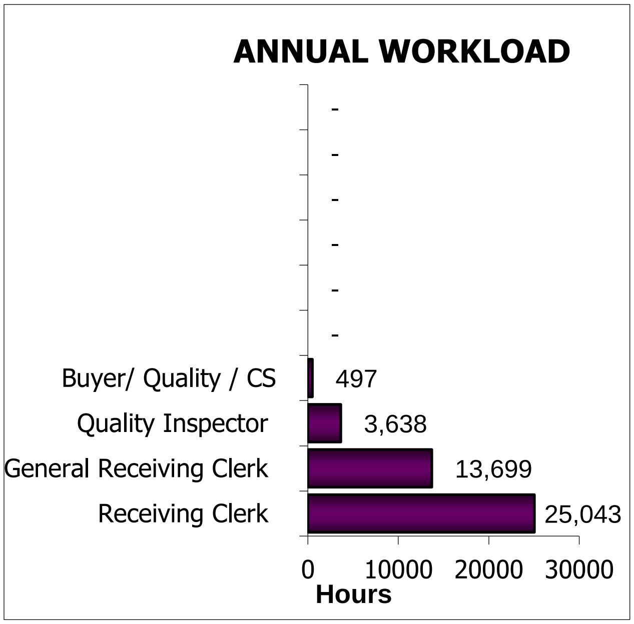
| | | | |
| **TOTAL** | **3,859** | **42,877** | **21.2** |




Total effective working time per lot inspection (of one process occurrence) was 3859 seconds or 64.3 minutes. Total annual effective working time of the process is 42,877 hrs which is equivalent to 22 FTEs. Receiving clerks had the highest annual work load with over 25,000 hrs (equivalent to 13 FTEs) spent on receiving inspection annually. General Receiving clerk spent 13,700 hrs (equivalent to 7 FTEs) spent on general receiving and warehouse bin storage. Quality Inspector annual work load is only 8% of total annual work load. Buyer/ Quality/ CS workload is the least, accounting for only 5% of total annual work load.

Annual work load was further used to evaluate the labor costs of each operator function and total annual costs.

| LABOUR COSTS | | |
|---|---|---|
| **Operator Function(s)** | **One process occurrence** | **All annual process occurrences** |
| Receiving Clerk | $32.67 | $1,306,605 |
| General Receiving Clerk | $17.87 | $714,746 |
| Quality Inspector | $7.33 | $293,325 |
| Buyer/ Quality / CS | $1.00 | $40,047 |
| | | |
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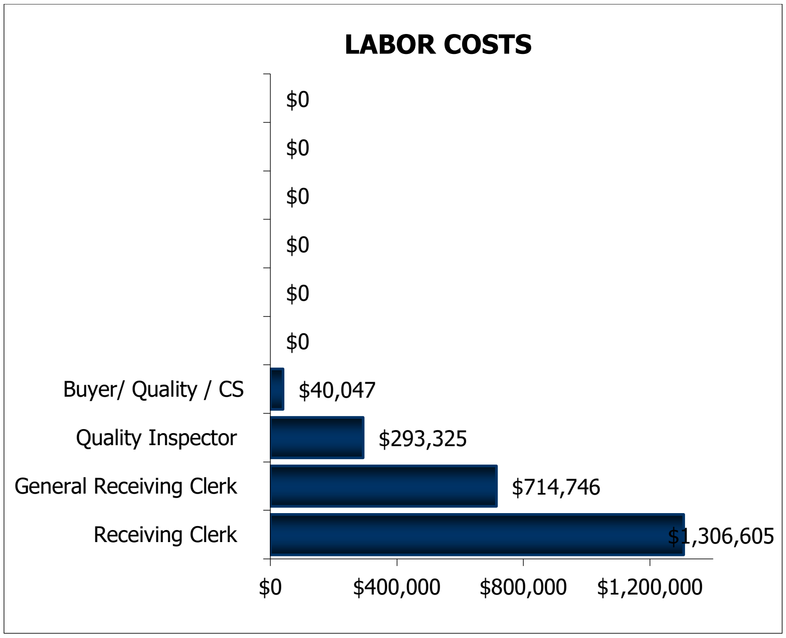
| | | |
| **TOTAL** | **$58.87** | **$2,354,723** |




Receiving Clerk, General Receiving Clerk, Quality Inspector, and Buyer/ Quality/ CS were expensed at $33, $18, $7, $1 per lot inspection. Total annual cost for inspection process was $2,354,723. Therefore, cycle time reduction to steps involved with Receiving Clerks and General Receiving Clerk would greatly cut down the labor costs, as well as their annual workloads.

## Goal Statement

A goal was established to help with achieving 98% monthly on time delivery target based on the current value stream total lead time of 12.5 hrs.

Achieve 1 hr or less total lead time per lot from receiving a lot to sending it to a warehouse bin storage

## Goal Matrix

| Goals | Our Current Performance | Best in Class | Target |
|---|---|---|---|
| Total Lead Time per Lot | 12.5 hrs – with supplier or quality waiting time | 64.3 min – without supplier or quality waiting time | 60.0 min or less |

## Determining Solutions

Per process VSM, work load, and labor cost analyses, improvement opportunities were identified for specific process steps. Steps were categorized into feasible, may be feasible, unfeasible options highlighted in green, yellow, and red respectively.

| Process Step ID | Process Step | Operator Labor Cost per Occurrence | Rationale for Categorization |
|---|---|---|---|
| 1 | Contact buyer for the tracking # and carrier # of the part number, and then see if parts have been delivered | $4.35 | Process change requires minimal capital |
| 2 | Grab a package or find the desired package | $2.51 | Process change requires minimal capital, but space is limited for change |
| 4 | Find the part dwg in DMS and determine receiving inspection requirements | $4.22 | Process change may/ may not require capital and alternate |

| | | | |
|---|---|---|---|
| | | | process is not identified with current resources. Most of the time spent waiting for DMS to respond |
| 8 | Record information in ERP, print company label and verify company label information against packing slip and also recorded information in ERP | $19.40 | Process change may/ may not require capital and alternate process is not identified with current resources. Most of the time spent typing information into ERP |
| 18 | Place packing slip on/ inside the package. Transfer the box to a pallet or the incoming Quality Inspector waiting shelf | $0.10 | Process change requires minimal capital |
| 20 | Find parts and packing slip, and transfer them from receiving staging to incoming inspection suite | $2.17 | Process change requires minimal capital |
| 26 | Email buyer/CS | $0.18 | Process change requires minimal capital |
| 27 | Receive in supplier paperwork | $0.36 | Process change requires minimal capital |
| 30 | Create new inspection sheet and enter in pertaining inspection specifications | $0.06 | Process change requires minimal capital |

| | | | |
|---|---|---|---|
| | and other information | | |
| 31 | Get Quality approval (4 hrs – 2 days) | $0.20 | Time mostly spent for waiting. Significant improvements needed to the Quality approval workflow to cut down waiting times |
| 42 | Check drawing, inspection sheet, and packing slip for accuracy and completeness and scan the paperwork into the drive | $0.59 | Process change requires minimal capital |
| 43 | Check scanned pages for the scanned order | $0.07 | Process change requires minimal capital |
| 47 | Receiving Clerk picks up the package, find a place in racking, transfer the package to a bin storage, and record the transaction in ERP | $12.26 | Process change may/ may not require capital and alternate process is not identified with current resources. Most of the time spent finding a place in racking and operating the forklift. |
| 7 and 27 | Receive in supplier paperwork (1 day - 1 week) | $0.34-0.04 | Time mostly spent for waiting. Significant supply chain improvements needed |
| 9, 17, and 37 | Contact Quality and a NCMR is created (1 day) | $0.08 | Improvements needed to the Quality NCMR workflow to cut down waiting time. But NCMR |

| | | | |
|---|---|---|---|
| | | | waiting time has no impact to the final lead time |

Based on the feasibility assessment of identified improvement opportunities, improvement opportunities were selected from the current VSM.

1. Total Cycle Time and average labor cost of one process occurrence –
   - ✓ Receiving clerk had to contact buyer and waited to receive the carrier and tracking # information
   - ✓ Quality Inspectors rescanned the same paperwork if the paperwork contained more than 10 pages, due to scanner capacity issues. On the other hand, a bigger scanner was purchased earlier for this purpose and that scanner missed pages during scanning
2. Part Identification and traceability –
   - ✓ Receiving clerks, General receiving clerks, and Quality Inspectors did not have a rejected parts containment shelf by their work stations
3. Part traceability and Visual Controls –
   - ✓ When Quality Inspectors arrived to receiving staging area to pick up parts, they first looked in the Quality Inspector waiting shelf and if the part was not be found on the shelf, they went around receiving staging area looking for parts
   - ✓ Quality Inspector had no on-hold visual control to identify WIP parts on hold for supplier paperwork and for inspection sheet approval
4. Process Errors –
   - ✓ For supplier paperwork waiting parts in the inspection suite, Quality Inspectors continued inspection. If the parts were accepted for dimensional inspection, then they stamped Quality Inspector approved seal with the green sticker on the box. Although the part was

waiting for paperwork, with the green sticker on the part could have been transferred to TX area, mixing with accepted incoming parts

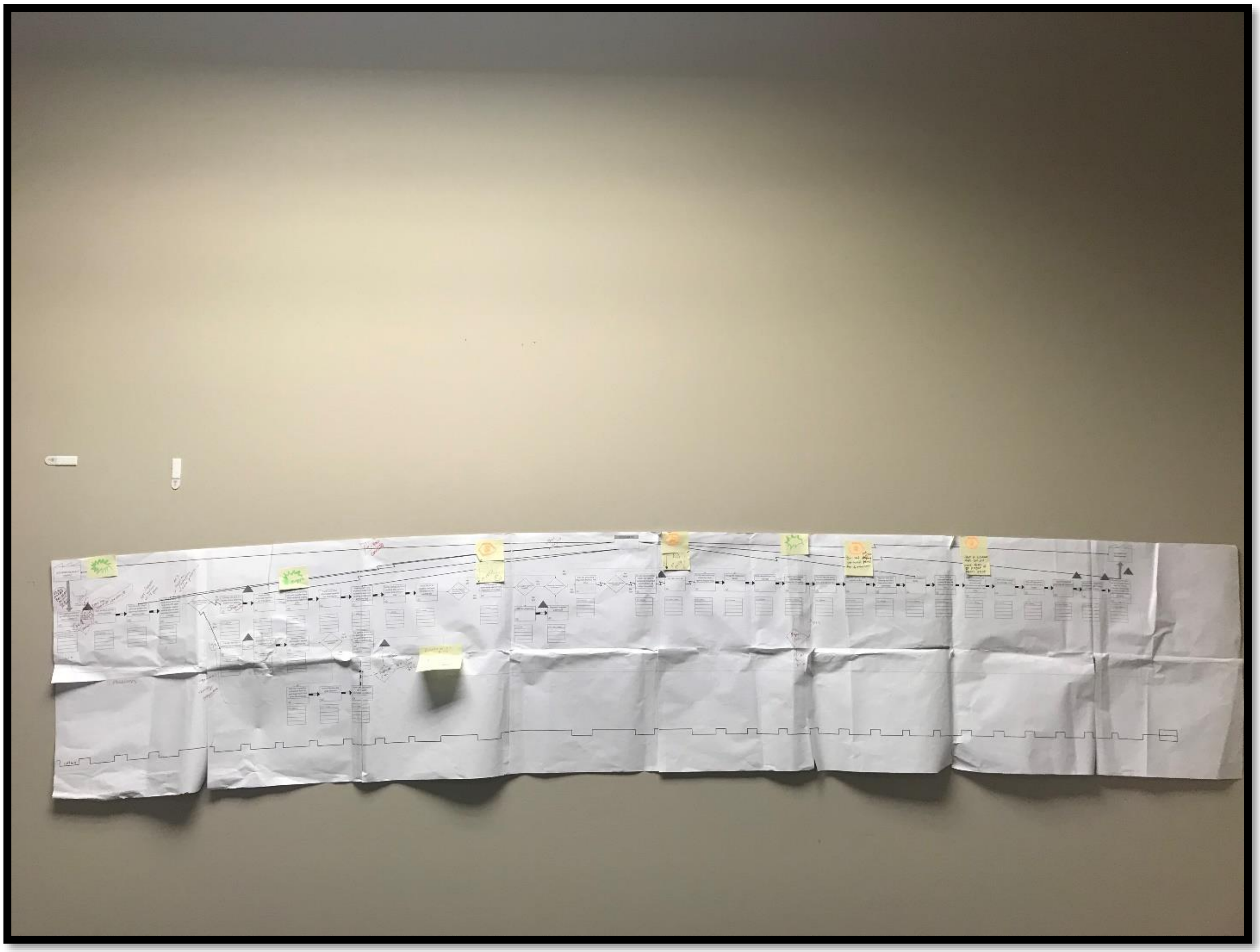
Solutions are proposed for improvement opportunities identified above.

| **Metric** | **Improvement Opportunity** | **Solution** | **Impacted Personnel** |
|---|---|---|---|
| Total Cycle Time and average labor cost of one process occurrence | Receiving clerk had to contact Buyer and waited to receive the carrier and tracking # information | Ask Buyer to add shipping carrier and tracking # into the hot list, for each part number | Receiving Clerks and Buyer |
| | Quality Inspectors rescanned the same paperwork if the paperwork contained more than 10 pages, due to scanner capacity issues. On the other hand, a bigger scanner was purchased earlier for this purpose and that scanner missed pages during scanning | Replace the scanner with a scanner that can scan pages and install a program to check for missing pages and order of scanned pages | Quality Inspectors |
| Part Identification and | Receiving clerks, General | Assign a shelf to store | Receiving Clerks, |

| | | | |
|---|---|---|---|
| traceability | receiving clerks, and Quality Inspectors did not have a rejected parts containment shelf by their work stations | reject parts during processing | General Receiving Clerks, and Quality Inspectors |
| Part traceability and Visual Controls | When Quality Inspectors arrived to receiving staging area to pick up parts, they first looked in the Quality Inspector waiting shelf and if the part was not be found on the shelf, they went around receiving staging area looking for parts. Sometimes the packing slip was misplaced when receiving clerk placed it on the box | Redo the layout of the receiving staging area with letter assigned areas. Place letter assigned location tags on a white board. Create a packing slip binder and have general receiving clerk drop off packing slip in the binder (NOT in or on the box) with the package assigned location tag attached to the packing slip. | Receiving Clerk and Quality Inspectors |
| | Quality Inspector had no on-hold visual control to identify WIP parts on hold for supplier | Add a white board displaying part numbers, lot #s on hold and their status | Quality Inspectors |

| | | | |
|---|---|---|---|
| | paperwork and for inspection sheet approval | | |
| Process Errors | For supplier paperwork waiting parts in the inspection suite, Quality Inspectors continued inspection. If the parts were accepted for dimensional inspection, then they stamped Quality Inspector approved seal with the green sticker on the box. Although the part was waiting for paperwork, with the green sticker on the part could have been transferred to TX area, mixing with accepted incoming parts | Mitigation is in place for this process error in the FMECA. Perform issue awareness to NOT continue with inspection if the WIP parts are on hold in the incoming inspection suite | Quality Inspectors |

## Current Value Stream Map – Working in Progress



## Future Value Stream Map

To create the future value stream map, solutions above were incorporated into the current value stream map, changed process steps, and added estimated times as new cycle times for those changed steps.

| **Solution** | **Impacted Step/s** | **Impacted Total Cycle Time** | **New Step** | **New Cycle Time** |
|---|---|---|---|---|
| Add shipping carrier and tracking # into the hot list, for each part number | Step 1: Contact buyer for the tracking # and carrier # of the part | 10 min | Step 1: Look up the tracking # and carrier # of the part number in | 1 min |

| | | | | |
|---|---|---|---|---|
| | number, and then see if parts have been delivered | | the hot list, and then see if parts have been delivered | |
| Replace the scanner with a scanner that can scan pages and install a program to check for missing pages and order of scanned pages | Step 42: Check drawing, inspection sheet, and packing slip for accuracy and completeness and scan the paperwork into the drive<br><br>Step 43: Check scanned pages for the scanned order | 4.5 min | Step 42: Check drawing, inspection sheet, and packing slip for accuracy and completeness and scan the paperwork into the drive<br><br>Step 43 removed as the scanning software will be checking for scanned order while its scanning | 2 min |
| Assign a shelf to store reject parts during processing | Steps 9, 17 and 37: Contact Quality and a NCMR is created | N/A | No step change; Added a reject kanban post and a shelf at | N/A |

| | | | | |
|---|---|---|---|---|
| | | | receiving, general receiving and incoming inspection reject steps | |
| Redo the layout of the receiving staging area with letter assigned areas. Place letter assigned location tags on a white board. Create a packing slip binder and have general receiving clerk drop off packing slip in the binder (NOT in or on the box) with the package assigned location tag attached to the packing slip. | Step 18: Place packing slip on/ inside the package. Transfer the box to a pallet or the incoming Quality Inspector waiting shelf<br><br>Step 20: Find parts and packing slip, and transfer them from receiving staging to incoming inspection suite | 15.68 min | Step 18: Put packing slip in the Packing slip binder, attach location tag with the packing slip. Transfer the package to assigned location space<br><br>Step 20:<br>Find packing slip and parts, and transfer them from receiving staging to incoming inspection suite | 3 min |

| | | | | |
|---|---|---|---|---|
| Add a white board displaying part numbers, lot #s on hold and their status | Steps 26, 27: Email buyer/CS, Receive in supplier paperwork<br><br>Steps 30, 31: Create new inspection sheet and enter in pertaining inspection specifications and other information, Get Quality approval | N/A | No step change; Added an WIP on-hold kanban system for the Quality Inspector on-hold shelf in the inspection suite to track part numbers, lot #s on hold for supplier paperwork and Quality approval | N/A |
| Mitigation is in place for this process error in the FMECA. Perform issue awareness to NOT continue with inspection if the WIP parts are on hold in the | Step 26: Email buyer/CS<br><br>Step 27: Receive in supplier paperwork | N/A | No step change; | N/A |

| | | | | |
|---|---|---|---|---|
| incoming inspection suite | | | | |

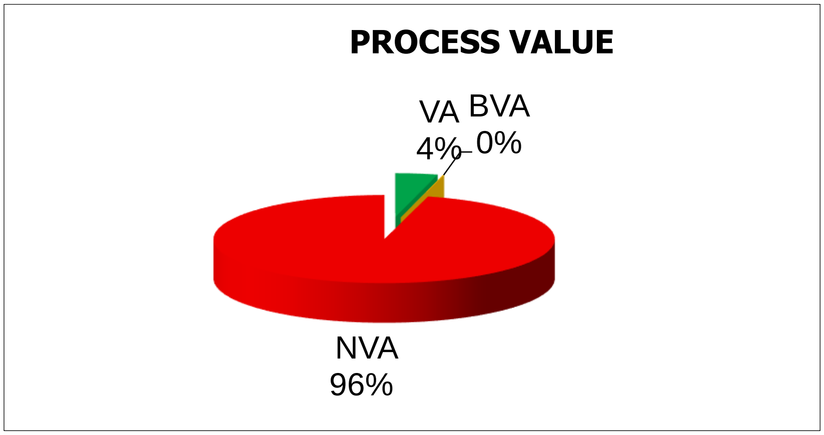
Future VSM.vsdx

## Future Value Stream Map Analysis

Process VSM summary, workload, and labor cost analyses are performed for future value steam map.

| **PROCESS VSM SUMMARY** | | | | |
|---|---|---|---|---|
| **Number of Annual Customer demands processed (Parts/Transactions/Files)** | 40,000 | | | |
| **Average labour cost of one process occurrence** | $53.15 | | | |
| **Total labour cost of all annual process occurrences** | $2,125,833 | | 19.3 | FTEs |
| **Times for One Process Occurrence** | **seconds** | **minutes** | **hours** | **days** |
| **Total Cycle time (Calendar time)** | 44,379 | 739.6 | 12.33 | 0.51 |
| **Effective Working Time (W/T)** | 3,519 | 58.6 | 0.98 | 0.04 |
| **Value Added Time (VA/T)** | 1,791 | 29.9 | 0.50 | 0.02 |
| **Business VALUE Added Time (BVA/T)** | 50 | 0.8 | 0.01 | 0.00 |
| **Non Value Added Time (NVA/T)** | 42,538 | 709.0 | 11.82 | 0.49 |
| **TAKT Time (transaction frequency)** | 182 | 3.0 | 0.1 | 0.00 |
| **PCE (Process Cycle Efficiency)** | 4.04% | | | |
| **Average Standard Work in Progress (WIP)** | 244 | **parts/files/transactions** | | |

Future value stream map total annual labor cost is $2,125,833. It is a $228,890 cost reduction from the current value stream map. Average labor cost per lot inspection is $53.15, $5.72 reduction from current status. This is mainly due to cutting down cycle times of both value-added steps and non-value-added steps that involved Receiving Clerks and Quality Inspectors. Effective working time was reduced as a result of cycle time reduction. Business value added times stayed the same, because business value added steps were not impacted by proposed changes. Takt time stayed the same because we assumed the number of annual customer demand processed and total # of annual effective working hours would stay the same in future as well.




Process value did not deviate from the current status – the process value still contained 96% non-value added, 4% value added and almost zero business value added.

| WORK LOAD | | | |
|---|---|---|---|
| **Operator Function(s)** | **One process occurrence (seconds)** | **All annual process occurrences (hours)** | **FTEs (Full Time Employees)** |
| Receiving Clerk | 2,014 | 22,377 | 11.1 |
| General Receiving Clerk | 1,233 | 13,699 | 6.8 |
| Quality Inspector | 227 | 2,525 | 1.2 |
| Buyer/ Quality/ CS | 45 | 497 | 0.2 |
| | | | |
| | | | |
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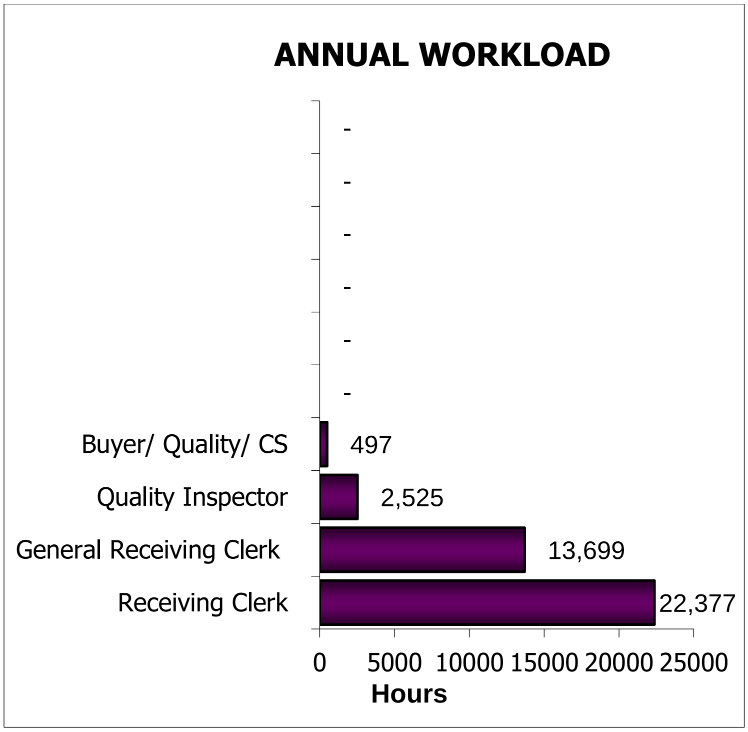
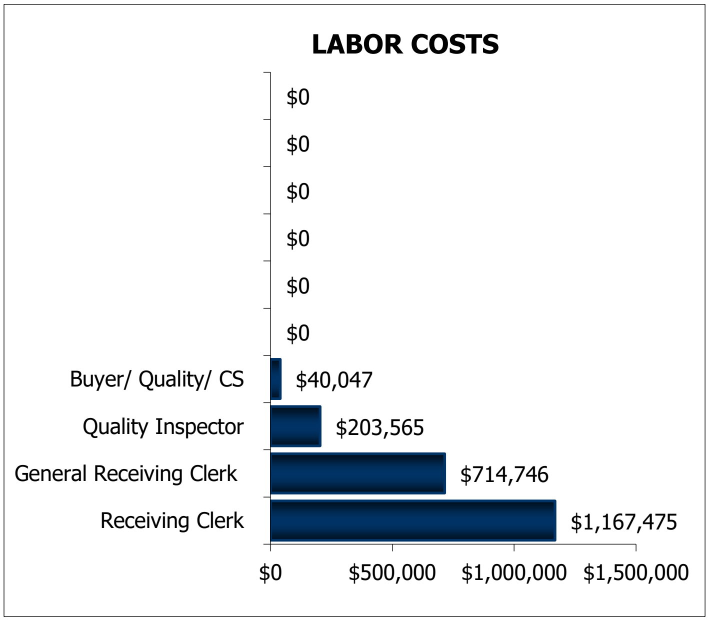
| | | | |
| | | | |
| | | | |
| **TOTAL** | **3,519** | **39,097** | **19.3** |




Total annual workload was reduced from 42,877 to 39,097 hrs, mainly due to work load reduction in Receiving Clerks and Quality Inspectors through process changes that impacted step 1 and steps 18/20. Annual workloads for receiving clerks were reduced from 25,043 to 22,377 hrs (12 FTEs VS 13 FTEs) and for Quality Inspectors was reduced from 3,638 to 2,525 hrs (2 FTEs unchanged). Thus, annual FTE's requirement was reduced from 21.2 to 19.3 FTEs. However, the annual work load is the same for Buyer/ Quality/ CS and General Receiving Clerk, since proposed changes had no effect on cycle times of those operator functions.

| LABOUR COSTS | | |
|---|---|---|
| **Operator Function(s)** | **One process occurrence** | **All annual process occurrences** |
| Receiving Clerk | $29.19 | $1,167,475 |
| General Receiving Clerk | $17.87 | $714,746 |
| Quality Inspector | $5.09 | $203,565 |
| Buyer/ Quality/ CS | $1.00 | $40,047 |
| | | |
| | | |
| | | |

| | | |
|---|---|---|
| | | |
| | | |
| | | |
| **TOTAL** | **$53.15** | **$2,125,833** |




| Attribute | Metric | Before | After |
|---|---|---|---|
| **Process** | Times for One Process Occurrence | | |
| | Total Cycle time (Calendar time) | 750.3 min | 739.6 min |
| | Effective Working Time (W/T) | 64.3 min | 58.6 min |
| | Value Added Time (VA/T) | 30.1 min | 29.9 min |
| | Business VALUE Added Time (BVA/T) | 0.8 min | 0.8 min |
| | Non Value Added Time (NVA/T) | 719.4 min | 709.0 min |
| | TAKT Time (transaction frequency) | 3.0 min | 3.0 min |
| | PCE (Process Cycle Efficiency) | 4.01% | 4.04% |
| **Work Load** | One process occurrence (minutes) | | |
| | Receiving Clerk | 37.6 | 33.6 |

| | | | |
|---|---|---|---|
| | General Receiving Clerk | 20.5 | 20.5 |
| | Quality Inspector | 5.5 | 3.8 |
| | Buyer/ Quality / CS | 0.7 | 0.7 |
| | TOTAL | 64.3 | 58.6 |
| | All annual process occurrences (hours) | | |
| | Receiving Clerk | 25043 | 22377 |
| | General Receiving Clerk | 13699 | 13699 |
| | Quality Inspector | 3638 | 2525 |
| | Buyer/ Quality / CS | 497 | 497 |
| | TOTAL | 42877 | 39097 |
| | FTEs (Full Time Employees) | | |
| | Receiving Clerk | 12.4 | 11.1 |
| | General Receiving Clerk | 6.8 | 6.8 |
| | Quality Inspector | 1.8 | 1.2 |
| | Buyer/ Quality / CS | 0.2 | 0.2 |
| | TOTAL | 21.2 | 19.3 |
| **Labor Cost** | One process occurrence (seconds) | | |
| | Receiving Clerk | $32.7 | $29.2 |
| | General Receiving Clerk | $17.9 | $17.9 |
| | Quality Inspector | $7.3 | $5.1 |
| | Buyer/ Quality / CS | $1.0 | $1.0 |
| | TOTAL | $58.9 | $53.1 |

| | All annual process occurrences (hours) | | |
|---|---|---|---|
| | Receiving Clerk | $1,306,605 | $1,167,475 |
| | General Receiving Clerk | $714,746 | $714,746 |
| | Quality Inspector | $293,325 | $203,565 |
| | Buyer/ Quality / CS | $40,047 | $40,047 |
| | TOTAL | $2,354,723 | $2,125,833 |

Labor cost per lot inspection was reduced from $58.87 to $53.15, incurring $5.72 per lot inspection. This resulted in annual savings of $228,890. Labor cost savings were primarily contributed by value added and non-value added work load reduction of receiving clerks followed by that of Quality Inspectors. Total lead time was reduced from 750.3 to 739.6 minutes. Overall, the process was able to cut down 10.7 minutes. Total lead time without supplier or quality waiting times (effective working time) per lot was reduced from 64.3 to 58.6 minutes. That is a 5.7 minute time reduction in every lot inspection from the internal (company) process itself without any regard to external (supplier or quality) waiting times. Supplier waiting times were 90% of the total lead time in future value stream map. Therefore, total lead time in the future value stream map would have met the target of 60 minutes, if supplier waiting times were significantly reduced.

# Recommendations and Conclusions

## Project Assignment and Roles

Future Value stream implementation responsibilities could be assigned to following personnel.

| Role | Responsibilities |
| --- | --- |
| Project Champion | Quality Engineer |
| Process Owner | Warehouse Manager |
| Leadership Team | VP of Operations, Operational Excellence Director |

## Project Team

Project team of six could be involved for future value stream implementation.

| Expertise | Will be involved in the implementation? |
| --- | --- |
| Receiving Clerk x 2 | Yes |
| General Receiving Clerk x 1 | Yes |
| Quality Inspector x 2 | Yes |
| Warehouse Manager | Yes |

## Recommendations for further improving the future value stream map

With regards to steps 7 and 27, Supplier waiting times accounted for 90% of the overall lead time. If supplier response workflow was improved to less than a minute, the target lead time per lot, 60 minutes, would be achieved. Therefore, supplier response workflow reanalysis may be prioritized.

Steps 2, 4, and 8 could be investigated further on alternate methods to reduce receiving clerk cycle times. Since receiving clerks had the highest annual work load, reducing cycle times on these steps would significantly decrease the cost of the overall inspection process.

For step 2, time was mostly spent on finding the desired package. Picking up the package or finding the desired package can be improved with a better receiving storage layout that allows the clerk to identify the package in less than 10 seconds.

For step 4, time was mostly spent of waiting for DMS to respond. Faster connectivity solutions may be pursued DMS response sensitivity.

For step 8, time was mostly being used for typing information into ERP. ERP Auto fill programs may be evaluated to cut down typing information from the packing slip.

For step 31, Quality approval workflow reanalysis would be required in order to cut down response waiting times from Quality.

In regard to Step 47 performed by general receiving clerk, time is mostly spent on finding a place in racking. A program may be developed with the ERP to display available bins for a specific size of package, not having to use the forklift often.

Other process steps may also be considered to investigate additional potential improvement opportunities.

Once future value stream map is implemented, control plan below can be executed to monitor the process and make sure that the process is in control.

| Measures | Evaluating | | | | Corrective Action |
|---|---|---|---|---|---|
| | **Standard** | **Data Recording** | **Data Collection** | **Data Analysis** | |
| Total Cycle time receiving clerk spends for incoming inspection excluded lot | Complete after implementation | X-bar control chart | ERP | QE | Report to OE Director |
| Total Cycle time receiving clerk spends for incoming inspection included lot | | X-bar control chart | ERP | QE | Report to OE Director |
| Cycle times for Step 1 and Step 18 | | X-bar control chart | Receiving Clerk | QE | Report to OE Director |
| Total Cycle time Quality Inspector spends until the lot is transferred to TX | | X-bar control chart | ERP | QE | Report to OE Director |
| Cycle times for Step 20 and Step 42 | | X-bar control chart | Quality Inspector | QE | Report to OE Director |
| Total Cycle time General Receiving Clerk spends for incoming inspection excluded lot | | X-bar control chart | ERP | QE | Report to OE Director |
| Total Cycle time General Receiving Clerk spends for incoming inspection included lot | | X-bar control chart | ERP | QE | Report to OE Director |

## Conclusions

Current process flow from receiving inspection to bin storage was traced, a process flow was developed, and cycle times of all process steps were recorded. For current value stream map analysis, lean based and quality-based metrics were defined, and kaizen bursts activities were identified in regard to lean and quality metrics. Kaizen burst activities were used to craft improvement opportunities, where they were incorporated into a new process map called, future value stream map. Future value stream map was developed with estimated cycle times on identified improvement opportunities and it was analyzed with respect to lean and quality metrics. Upon analysis, future value stream map was predicted to reduce labor cost by $5.72 per lot. This predicted annual savings of $228,890. Labor cost savings were primarily contributed by value added and non-value added work load reduction of receiving clerks followed by that of Quality Inspectors. Total lead time was predicted to be at 739.6 minutes, 10.7 minutes reduced per lot from current process. Total lead time without supplier or quality waiting times (effective working time) per lot was predicted to be 58.6 minutes, which met the target lead time of 60 minutes or less. That was a 5.7 minute time reduction per lot inspection from the internal (company) current process itself without any regard to external (supplier or quality) waiting times. 90% of total lead time included supplier waiting time. Therefore, total lead time in the future value stream map could be further improved if supplier waiting times were significantly reduced which would lead into achieving total lead time target of 60 minutes or less.

Annual workloads for receiving clerks was reduced from 25,043 to 22,377 hrs (12 FTEs VS 13 FTEs) and for Quality Inspectors was reduced from 3,638 to 2,525 hrs (2 FTEs unchanged). Thus, annual FTE's requirement was reduced from 21.2 to 19.3 FTEs. However, the annual work load is the same for Buyer/ Quality/ CS and General Receiving Clerk.

Supplier waiting times had the most impact (90%) on the overall lead time in the future value stream map. If supplier response workflow was improved to less than a minute, the target lead time would be achieved. Therefore, supplier response workflow reanalysis may be prioritized. Additionally, Steps 2, 4, and 8 can be investigated further on alternate methods to reduce receiving clerk cycle times. Since receiving clerks have the highest annual work load, reducing cycle times on these steps would significantly drive cost down of the overall inspection process. In regards to step 31, Quality approval workflow reanalysis would be required in order to cut down response waiting times from Quality. Step 47 and other process steps may also be considered to investigate additional potential improvement opportunities. Once future value stream map is implemented, a control plan may be executed to monitor the process and make sure that the process is in control.

# References

[1] Rother, M., Shook, J., Womack, J. P., & Jones, D. T. (2009). Learning to see: Value-stream mapping to create value and eliminate muda. Cambridge (Mass.: The Lean Enterprise Institute.

[2] Strub, F. (2010). Equable - Business Operations Excellence - Lean Six Sigma. Retrieved from http://equable-us.com

# Appendix A

## Value Stream Mapping Calculator [2]

FINAL
VSM_calculator.xlsx

## Material Flow Calculations

Following material flow equations were used to calculate current value stream and future value stream lean metrics.

*Equation 1*

$$Total\ \#\ of\ effective\ working\ hours = Total\ \#\ of\ working\ days\ per\ day\ x\ \#\ of\ Effective\ working\ hrs\ per\ day$$

*Equation 2*

$$\#\ of\ Annual\ occurences\ per\ step = \%\ Total\ flow\ through\ step\ x\ \#\ of\ Annual\ demands\ processsed$$

*Equation 3*

$$Weighted\ step\ cycle\ time\ or\ effective\ working\ time\ or\ value\ added\ or\ business\ value\ added\ time = Step\ cycle\ time\ or\ working\ time\ or\ value\ added\ time\ or\ business\ value\ added\ time\ x\ \#\ of\ Annual\ occurences\ per\ step)$$

*Equation 4*

$$Weighted\ Step\ operator\ labor\ cost = \frac{Weighted\ step\ effective\ working\ time\ x\ Annual\ salary\ of\ operator\ labor\ cost}{Total\ \#\ of\ effective\ working\ hrs\ per\ year\ x\ 3600}$$

*Equation 5*

$$Average\ labor\ cost\ of\ one\ process\ occurence = Total\ Labor\ cost\ of\ one\ process\ occurence$$

*Equation 6*

$$Total\ cycle\ time = \Sigma Weighted\ step\ cycle\ time\ step\ 1\ through\ step\ 47$$

*Equation 7*

$$Effective\ working\ time = \Sigma\ \text{Weighted step effective working time}\ step\ 1\ through\ step\ 47$$

*Equation 8*

$$Value\ added\ time = \Sigma\ Weighted\ step\ value\ added\ time\ step\ 1\ through\ step\ 47$$

*Equation 9*

$$Business\ value\ added\ time = \Sigma\ \text{Weighted step business value added}\ step\ 1\ through\ step\ 47$$

*Equation 10*

$$Non\ value\ added\ time = Total\ cycle\ time - Value\ added\ time - Business\ value\ added\ time$$

*Equation 11*

$$TAKT\ Time = \frac{Total\ \#\ of\ effective\ working\ hrs\ per\ year}{\#\ of\ Annual\ customer\ demands\ processed}$$

*Equation 12*

$$Process\ Cycle\ Efficiency = \frac{Value\ added\ time}{Total\ cycle\ time} * 100\%$$

*Equation 13*

$$Value\ added\ or\ Nonvalue\ added\ or\ Business\ value\ added\ \% =$$

$$\frac{Value\ added\ or\ Nonvalue\ added\ or\ Business\ value\ added\ time}{Total\ cycle\ time} * 100\%$$

*Equation 14*

$$\text{Work load of One process occurence per opeartor function}$$
$$= \Sigma\text{Weighted Step Effective Working Time from } step\ 1\ through\ step\ 47 \text{ per operator function}$$

*Equation 15*

$$\text{Total Work load of one process occurence}$$
$$= \Sigma \text{ Work load of one process occurence of all operator functions}$$

*Equation 16*

$$\text{Annual Work load of all process occurences per opeartor function}$$
$$= \text{\# of Annual customer demands processed x Work load of One process occurence per opeartor function}$$

*Equation 17*

$$\text{Total annual work load of all process occurences}$$
$$= \Sigma \text{ Work load of all process occurences of all operator functions}$$

*Equation 18*

$$FTEs\ per\ operator\ fucntion$$
$$= \frac{Total\ Time\ of\ all\ annual\ process\ occurences\ for\ operator\ function}{Total\ \#\ of\ effective\ working\ hrs\ per\ year}$$

*Equation 19*

$$\text{Total FTEs} = \Sigma \text{ FTEs of all operator functions}$$

*Equation 20*

$$Labor\ cost\ of\ one\ process\ occurence\ per\ operator\ function$$
$$= \Sigma\ Weighted\ step\ operator\ labor\ cost\ step\ 1\ through\ step\ 47\ per\ operator\ function\ x\ \#\ of\ Annual\ occurences\ processed\ per\ step$$

*Equation 21*

$$\textit{Total Labor cost of one process occurence} = \Sigma\ \textit{Labor cost of one process occurence of all operator functions}$$

*Equation 22*

$$\textit{Labor cost of all annual process occurences per operator function}$$
$$= \textit{Labor Cost of one process occurence per operator function x \# of Annual customer demands processed}$$

*Equation 23*

$$\textit{Total Labor cost of all annual process occurences}$$
$$= \Sigma\ \textit{Labor cost of all annual process occurences of all operator functions}$$